

Maryland Tutorials are designed specifically for the Maryland College and Career-Ready Standards to prepare students for the PARCC assessment, the Maryland School Assessment (MSA), and the Maryland High School Assessment (HSA).

Math Tutorials offer targeted instruction, practice and review designed to develop computational fluency, deepen conceptual understanding, and apply mathematical practices. They automatically identify and address learning gaps down to elementary-level content, using adaptive remediation to bring students to grade-level no matter where they start. Students engage with the content in an interactive, feedback-rich environment as they progress through standards-aligned modules. By constantly honing the ability to apply their knowledge in abstract and real world scenarios, students build the depth of knowledge and higher order skills required to demonstrate their mastery when put to the test.

In each module, the Learn It and Try It make complex ideas accessible to students through focused content, modeled logic and process, multi-modal representations, and personalized feedback as students reason through increasingly challenging problems. The Review It offers a high impact summary of key concepts and relates those concepts to students' lives. The Test It assesses students' mastery of the module's concepts, providing granular performance data to students and teachers after each attempt. To help students focus on the content most relevant to them, unit-level pretests and posttests can quickly identify where students are strong and where they're still learning.

### Unit 1: Relationships Between Quantities

- **MONITORING PRECISION AND ACCURACY**

- N.Q.1.A: Relationships between Quantities and Reasoning with Equations Reason quantitatively and use units to solve problems. 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. Ability to choose appropriate units of measure to represent context of the problem
- N.Q.1.B: Relationships between Quantities and Reasoning with Equations Reason quantitatively and use units to solve problems. 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. Ability to convert units of measure using dimensional analysis
- N.Q.2.A: Relationships between Quantities and Reasoning with Equations Reason quantitatively and use units to solve problems. Define appropriate quantities for the purpose of descriptive modeling. Ability to select and use units of measure to accurately model a given real world scenario
- N.Q.3.A: Relationships between Quantities and Reasoning with Equations Reason quantitatively and use units to solve problems. Choose a level of accuracy appropriate to limitations on measurement

when reporting quantities. Knowledge of and ability to apply rules of significant digits

- N.Q.3.B: Relationships between Quantities and Reasoning with Equations Reason quantitatively and use units to solve problems. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. Ability to use precision of initial measurements to determine the level of precision with which answers can be reported

- **ONE-STEP EQUATIONS AND INEQUALITIES**

- A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality
- A.CED.1.A: Expressions and Equations Create equations that describe numbers or relationships Create equations and inequalities in one variable and use them to solve problems. Ability to distinguish between linear, quadratic and exponential relationships given the verbal, numeric and/or graphic representations
- A.REI.1.A: Relationships between Quantities and Reasoning with Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step
- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- A.REI.1.A: Expressions and Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step

- **MULTI-STEP EQUATIONS AND INEQUALITIES**

- A.REI.1.A: Relationships between Quantities and Reasoning with Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step
- A.REI.1.A: Expressions and Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step

- A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality
- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- A.CED.1.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations and inequalities in one variable and use them to solve problems. Ability to distinguish between linear and exponential relationships given multiple representations and then create the appropriate equation/inequality using given information

## Unit 2: Axioms of Equality and Literal Equations

### • AXIOMS OF EQUALITY

- A.SSE.2.A: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to use properties of mathematics to alter the structure of an expression
- A.REI.1.A: Relationships between Quantities and Reasoning with Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step
- A.REI.1.A: Expressions and Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step

### • LITERAL EQUATIONS

- A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality

- A.CED.4.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. Ability to recognize/create equivalent forms of literal equations
- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- A.REI.4.a.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Use the method of completing the square to transform any quadratic equation in  $x$  into an equation of the form  $(x - p) = q$  that has the same solutions. Derive the quadratic formula from this form. Ability to solve literal equations for a variable of interest
- A.REI.4.a.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Use the method of completing the square to transform any quadratic equation in  $x$  into an equation of the form  $(x - p) = q$  that has the same solutions. Derive the quadratic formula from this form. Ability to solve literal equations for a variable of interest
- A.CED.4.A: Expressions and Equations Create equations that describe numbers or relationships Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. Ability to recognize and create different forms of literal equations
- A.REI.4.a.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Use the method of completing the square to transform any quadratic equation in  $x$  into an equation of the form  $(x - p) = q$  that has the same solutions. Derive the quadratic formula from this form. Ability to solve literal equations for a variable of interest

### Unit 3: Writing Expressions and Equations

#### • FORMULATING AND SIMPLIFYING ALGEBRAIC EXPRESSIONS

- A.SSE.1.a.1: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to make connections between symbolic representations and proper mathematics vocabulary
- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- A.SSE.1.b.1: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret complicated expressions by viewing one or more of their parts as a single entity. Ability to interpret and apply rules for order of operations
- A.SSE.2.A: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to use properties of mathematics to alter the structure

of an expression

- A.SSE.2.B: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to select and then use an appropriate factoring technique

- **FORMULATING AND SOLVING EQUATIONS FROM WORD PROBLEMS**

- A.SSE.1.a.1: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to make connections between symbolic representations and proper mathematics vocabulary
- F.LE.1.b.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. Ability to recognize a linear relationship
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- A.CED.1.A: Expressions and Equations Create equations that describe numbers or relationships Create equations and inequalities in one variable and use them to solve problems. Ability to distinguish between linear, quadratic and exponential relationships given the verbal, numeric and/or graphic representations
- A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality
- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.

- **FORMULATING AND SOLVING INEQUALITIES FROM WORD PROBLEMS**

- A.SSE.1.a.1: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to make connections between symbolic representations and proper mathematics vocabulary
- A.CED.1.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations and inequalities in one variable and use them to solve problems. Ability to distinguish between linear and exponential relationships given multiple representations and then create the appropriate equation/inequality using given information

- A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality
- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context

#### Unit 4: Functions

- **FUNCTIONS AND RELATIONS**

- F.IF.1.C: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to use of function notation
- F.IF.1.C: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to use of function notation
- F.IF.2.A: Linear and Exponential Relationships Understand the concept of a function and use function notation Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. Ability to make connections between context and algebraic representations which use function notation
- F.IF.1.C: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to use of function notation
- F.IF.1.A: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to determine if a relation is a function

- F.IF.1.A: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to determine if a relation is a function
- F.IF.1.D: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Knowledge of and ability to apply the vertical line test
- F.IF.1.A: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to determine if a relation is a function
- F.IF.1.B: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to identify the domain and range of a function from multiple representations
- F.IF.1.C: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to use of function notation
- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
- F.IF.5.C: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to recognize and use alternate vocabulary for domain and range such as input/output or independent/dependent
- F.IF.7.b.2: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Ability to make connections between a functions domain and range and the appearance of the graph of the function

- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- **DOMAIN AND RANGE**
  - F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
  - F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
  - F.IF.5.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of a function based on real world context
  - F.IF.1.B: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to identify the domain and range of a function from multiple representations
  - F.IF.5.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
  - F.IF.5.C: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to recognize and use alternate vocabulary for domain and range such as input/output or independent/dependent
- **EVALUATING FUNCTIONS**
  - F.IF.1.C: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to use of function notation

- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.IF.1.C: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to use of function notation
- F.IF.2.A: Linear and Exponential Relationships Understand the concept of a function and use function notation Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. Ability to make connections between context and algebraic representations which use function notation
- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
- F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
- F.IF.5.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of a function based on real world context

### Unit 5: Introduction to Linear Relationships

- **SLOPE**

- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.IF.6.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations

- F.IF.6.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.IF.6.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Knowledge that the rate of change of a function can be positive, negative or zero
- **GRAPHING AND ANALYZING LINEAR FUNCTIONS**
  - F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
  - F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
  - F.IF.1.B: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to identify the domain and range of a function from multiple representations
  - F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
  - F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
  - F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
  - F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions

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**Unit 6: Graphs of Linear Equations and Inequalities****• GRAPHING AND MANIPULATING  $Y = MX + B$** 

- F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
- F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function
- A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
- F.IF.6.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.LE.5.A: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to interpret the slope and y-intercept of a linear model in terms of context
- F.IF.6.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function
- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations

- F.LE.1.b.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. Ability to recognize a linear relationship
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- F.IF.7.a.1: Linear and Exponential Relationships Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. See the skills and knowledge that are stated in the Standard.
- **GRAPHS OF LINEAR INEQUALITIES**
  - A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality
  - A.REI.12.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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. Ability to explain why a particular shaded region represents the solution of a given linear inequality or system of linear inequalities
  - A.REI.12.B: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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. Ability to convey the mathematics behind the dotted versus solid boundary lines used when graphing the solutions to linear inequalities
  - A.CED.3.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships 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. Ability to distinguish between a mathematical solution and a contextual solution

## Unit 7: Linear Equations

- **SLOPE-INTERCEPT FORM OF A LINEAR EQUATION**
  - F.LE.5.A: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to interpret the slope and y-intercept of a linear model in terms of context

- F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- A.REI.10.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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). Ability to construct an argument as to how the points that make up a curve connect to an algebraic representation of the function that is being represented by the graph
- F.IF.6.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.IF.6.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- **POINT-SLOPE FORM OF A LINEAR EQUATION**
  - F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
  - F.LE.1.b.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. Ability to recognize a linear relationship
  - F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model

- F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function

## Unit 8: Introduction to Two-Variable Linear Systems

### • SOLVING SYSTEMS OF LINEAR EQUATIONS: GUESS AND CHECK

- A.CED.3.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships 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. Ability to distinguish between a mathematical solution and a contextual solution
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- A.CED.2.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to distinguish between linear and exponential relationships given multiple representations
- F.IF.2.A: Linear and Exponential Relationships Understand the concept of a function and use function notation Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. Ability to make connections between context and algebraic representations which use function notation
- A.REI.6.A: Linear and Exponential Relationships Solve systems of equations Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables. Ability to extend experiences with solving simultaneous linear equations from 8EE.8 b&c to include more complex situations
- A.REI.5.A: Linear and Exponential Relationships Solve systems of equations 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. Ability to use various methods for solving systems of equations algebraically

### • SOLVING SYSTEMS OF LINEAR EQUATIONS: GRAPHING

- A.REI.6.A: Linear and Exponential Relationships Solve systems of equations Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables. Ability to extend experiences with solving simultaneous linear equations from 8EE.8 b&c to include more complex situations
- A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically Explain why the  $x$ -coordinates of the points where the graphs of the equations  $y = f(x)$  and

$y = (x)$  intersect are the solutions of the equation  $f(x) = (x)$ ; 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  $(x)$  are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Ability to show the equality of two functions using multiple representations

- A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
- A.CED.3.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships 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. Ability to distinguish between a mathematical solution and a contextual solution

### Unit 9: Solving Two-Variable Linear Systems

#### • SOLVING SYSTEMS OF LINEAR EQUATIONS: SUBSTITUTION

- A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
- A.CED.3.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships 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. Ability to distinguish between a mathematical solution and a contextual solution
- A.CED.2.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to distinguish between linear and exponential relationships given multiple representations
- A.REI.5.A: Linear and Exponential Relationships Solve systems of equations 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. Ability to use various methods for solving systems of equations algebraically
- A.REI.6.A: Linear and Exponential Relationships Solve systems of equations Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables. Ability to extend experiences with solving simultaneous linear equations from 8EE.8 b&c to include more complex situations

#### • SOLVING SYSTEMS OF LINEAR EQUATIONS: ELIMINATION

- A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent

relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation

- A.REI.5.A: Linear and Exponential Relationships Solve systems of equations 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. Ability to use various methods for solving systems of equations algebraically
- A.REI.6.A: Linear and Exponential Relationships Solve systems of equations Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables. Ability to extend experiences with solving simultaneous linear equations from 8EE.8 b&c to include more complex situations
- A.CED.3.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships 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. Ability to distinguish between a mathematical solution and a contextual solution
- **SOLVING SYSTEMS OF LINEAR INEQUALITIES**
  - A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
  - A.REI.3.B: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to accurately perform the steps needed to solve a linear equation/inequality
  - A.REI.12.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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. Ability to explain why a particular shaded region represents the solution of a given linear inequality or system of linear inequalities
  - A.REI.12.B: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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. Ability to convey the mathematics behind the dotted versus solid boundary lines used when graphing the solutions to linear inequalities
  - A.CED.3.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships 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. Ability to distinguish between a mathematical solution and a contextual solution

## Unit 10: Introduction to Exponential Functions

### • EXPONENTIAL FUNCTIONS

- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.SSE.1.a.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to include quadratic and exponential expressions
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- A.REI.10.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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). Ability to construct an argument as to how the points that make up a curve connect to an algebraic representation of the function that is being represented by the graph
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- F.LE.5.C: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to interpret the rate of increase/decrease in an exponential model
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
- A.CED.1.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations and inequalities in one variable and use them to

solve problems. Ability to distinguish between linear and exponential relationships given multiple representations and then create the appropriate equation/inequality using given information

- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.LE.1.c.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. Ability to recognize an exponential relationship
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.SSE.1.b.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret complicated expressions by viewing one or more of their parts as a single entity. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to quadratic and exponential expressions
- A.SSE.3.c.1: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Use the properties of exponents to transform expressions for exponential functions. Ability to connect experience with properties of exponents from Unit 2 of this course to more complex expressions
- **EXPONENTIAL GROWTH AND DECAY**
  - A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
  - F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model

- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.SSE.1.a.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to include quadratic and exponential expressions
- A.SSE.1.b.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret complicated expressions by viewing one or more of their parts as a single entity. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to quadratic and exponential expressions
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- F.LE.1.a.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. See the skills and knowledge that are stated in the Standard.
- F.LE.1.b.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. Ability to recognize a linear relationship
- F.LE.3.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Observe using graphs and tables that a quantity increasing

exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function. See the skills and knowledge that are stated in the Standard.

- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.CED.2.A: Expressions and Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to distinguish between linear, quadratic and exponential relationships given numeric, or verbal representations
- A.CED.1.A: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations and inequalities in one variable and use them to solve problems. Ability to distinguish between linear and exponential relationships given multiple representations and then create the appropriate equation/inequality using given information
- F.LE.1.c.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. Ability to recognize an exponential relationship
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )

## Unit 11: Examining Exponential Relationships

### • SOLVING EXPONENTIAL INEQUALITIES

- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.SSE.1.b.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret complicated expressions by viewing one or

more of their parts as a single entity. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to quadratic and exponential expressions

- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
- A.REI.3.A: Relationships between Quantities and Reasoning with Equations Solve equations and inequalities in one variable Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters. Ability to analyze the structure of an equation to determine the sequence of steps that need to be applied to arrive at a solution
- F.LE.1.c.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. Ability to recognize an exponential relationship
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- A.CED.2.B: Expressions and Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation
- **LINEAR AND EXPONENTIAL PARENT FUNCTIONS**
  - F.IF.7.b.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Ability to make a quick sketch of each parent function over the set of real numbers
  - F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
  - F.IF.7.b.3: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined

functions, including step functions and absolute value functions. Knowledge of how parameters introduced into a function alter the shape of the graph of the parent function

- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
- F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
- F.IF.5.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of a function based on real world context
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )
- **TRANSFORMATIONS OF THE LINEAR AND EXPONENTIAL PARENT FUNCTIONS**
  - F.IF.7.b.3: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Knowledge of how parameters introduced into a function alter the shape of the graph of the parent function
  - F.BF.3.A: Linear and Exponential Relationships Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. See the skills and knowledge that are stated in the Standard.

## Unit 12: Sequences

- **SEQUENCES**
  - F.IF.3.A: Linear and Exponential Relationships Understand the concept of a function and use function notation Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. See the skills and knowledge that are stated in the Standard.
  - F.BF.1.a.1: Linear and Exponential Relationships Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an

explicit expression, a recursive process, or steps for calculation from a context. See the skills and knowledge that are stated in the Standard.

- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model

- **ARITHMETIC AND GEOMETRIC SEQUENCES**

- F.IF.2.A: Linear and Exponential Relationships Understand the concept of a function and use function notation Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. Ability to make connections between context and algebraic representations which use function notation
- F.IF.3.A: Linear and Exponential Relationships Understand the concept of a function and use function notation Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. See the skills and knowledge that are stated in the Standard.
- F.BF.1.a.1: Linear and Exponential Relationships Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. See the skills and knowledge that are stated in the Standard.
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model

### Unit 13: Statistics

- **DATA ANALYSIS**

- S.ID.1.A: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Represent data with plots on the real number line (dot plots, histograms, and box plots). Ability to determine the best data representation to use for a given situation
- S.ID.1.B: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Represent data with plots on the real number line (dot plots, histograms, and box plots). Knowledge of key features of each plot
- S.ID.1.C: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Represent data with plots on the real number line (dot plots, histograms, and box plots). Ability to correctly display given data in an appropriate plot
- S.ID.1.D: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Represent data with plots on the real number line (dot plots, histograms, and box plots). Ability to analyze data given in different formats
- S.ID.5.A: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables 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. Knowledge of the characteristics of categorical data

- S.ID.2.A: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable 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. Ability to interpret measures of center and spread (variability) as they relate to several data sets
- S.ID.2.B: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable 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. Ability to identify shapes of distributions (skewed left or right, bell, uniform, symmetric)
- S.ID.3.B: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). Ability to recognize extreme data points(outliers) and their impact on center
- S.ID.3.C: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). Ability to effectively communicate what the data reveals
- S.ID.3.D: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). Knowledge that when comparing distributions there must be common scales and units
- **FREQUENCY TABLES**
  - S.ID.5.B: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables 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. Ability to read and use a two-way frequency table
  - S.ID.5.A: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables 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. Knowledge of the characteristics of categorical data
  - S.ID.5.C: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables 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. Ability to use and to compute joint, marginal, and conditional relative frequencies

- S.ID.3.A: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). Ability to recognize gaps, clusters, and trends in the data set

## Unit 14: Two-Variable Data

### • SCATTERPLOTS

- S.ID.6.b.1: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to create a graphic display of residuals
- S.ID.6.c.1: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a linear function for a scatter plot that suggests a linear association. Ability to recognize a linear relationship displayed in a scatter plot
- S.ID.6.b.4: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to analyze the meaning of patterns in residual plots
- S.ID.9.A: Descriptive Statistics Interpret linear models Distinguish between correlation and causation. Ability to provide examples of two variables that have a strong correlation but one does not cause the other
- S.ID.6.a.2: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Ability to create and use regression models to represent a contextual situation
- S.ID.6.b.2: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to recognize patterns in residual plots
- F.IF.6.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.LE.5.A: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to interpret the slope and y-intercept of a linear model in terms of context
- S.ID.6.c.2: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe

how the variables are related. Fit a linear function for a scatter plot that suggests a linear association. Ability to determine an equation for the line of best fit for a set of data points

- F.IF.6.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- S.ID.7.A: Descriptive Statistics Interpret linear models Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. See the skills and knowledge that are stated in the Standard.
- **SCATTERPLOTS AND MODELING**
  - S.ID.6.a.2: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Ability to create and use regression models to represent a contextual situation
  - S.ID.6.b.1: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to create a graphic display of residuals
  - S.ID.6.c.2: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a linear function for a scatter plot that suggests a linear association. Ability to determine an equation for the line of best fit for a set of data points
  - S.ID.1.B: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Represent data with plots on the real number line (dot plots, histograms, and box plots). Knowledge of key features of each plot
  - S.ID.3.A: Descriptive Statistics Summarize, represent, and interpret data on a single count or measurement variable Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). Ability to recognize gaps, clusters, and trends in the data set
  - S.ID.6.b.3: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to calculate error margins (residuals) with a calculator
  - S.ID.6.b.4: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to analyze the meaning of patterns in residual plots

- S.ID.6.b.2: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Informally assess the fit of a function by plotting and analyzing residuals. Ability to recognize patterns in residual plots
- S.ID.6.c.1: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a linear function for a scatter plot that suggests a linear association. Ability to recognize a linear relationship displayed in a scatter plot
- S.ID.8.B: Descriptive Statistics Interpret linear models Compute (using technology) and interpret the correlation coefficient of a linear fit. Ability to compute and analyze the correlation coefficient for the purpose of communicating the goodness of fit of a linear model for a given data set
- S.ID.6.a.1: Descriptive Statistics Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Ability to recognize types of relationships that lend themselves to linear and exponential models
- S.ID.8.A: Descriptive Statistics Interpret linear models Compute (using technology) and interpret the correlation coefficient of a linear fit. Knowledge of the range of the values  $(-1 \leq r \leq 1)$  and the interpretation of those values for correlation coefficients
- S.ID.6.a.2: Quadratic Functions and Modeling Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Ability to identify which model is most appropriate; linear, exponential or quadratic
- S.ID.7.A: Descriptive Statistics Interpret linear models Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. See the skills and knowledge that are stated in the Standard.
- S.ID.6.a.1: Quadratic Functions and Modeling Summarize, represent, and interpret data on two categorical and quantitative variables Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Ability to fit a quadratic function to a set of data in a modeling context
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model  $(f(0) = b + k = 1 + k)$

## Unit 15: Real Number System

### • LAWS OF EXPONENTS

- A.SSE.2.A: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to use properties of mathematics to alter the structure

of an expression

- N.RN.2.A: Expressions and Equations Extend the properties of exponents to rational exponents. Rewrite expressions involving radicals and rational exponents using the properties of exponents. Ability to use properties of radicals and rational exponents to transform and simplify radical expressions
- A.REI.1.A: Relationships between Quantities and Reasoning with Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step
- A.REI.1.A: Expressions and Equations Understand solving equations as a process of reasoning and explain the reasoning 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. Ability to identify the mathematical property (addition property of equality, distributive property, etc.) used at each step in the solution process as a means of justifying a step
- **OPERATIONS ON RATIONAL AND IRRATIONAL NUMBERS**
  - N.RN.3.A: Expressions and Equations Use properties of rational and irrational numbers. 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. Ability to perform operations on both rational and irrational numbers
  - N.RN.3.B: Expressions and Equations Use properties of rational and irrational numbers. 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. Make generalizations about sums and products of rational and irrational numbers

## Unit 16: Polynomials

- **POLYNOMIAL BASICS**
  - A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
  - A.SSE.1.a.1: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to make connections between symbolic representations and proper mathematics vocabulary
- **ADDITION AND SUBTRACTION OF POLYNOMIALS**

- A.APR.1.A: Expressions and Equations Perform arithmetic operations on polynomials 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. Ability to show that when polynomials are added, subtracted or multiplied that the result is another polynomial
- **MULTIPLICATION OF POLYNOMIALS**
- A.APR.1.A: Expressions and Equations Perform arithmetic operations on polynomials 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. Ability to show that when polynomials are added, subtracted or multiplied that the result is another polynomial

## Unit 17: Factoring Polynomials

- **FACTORING QUADRATIC TRINOMIALS**

- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- A.SSE.3.a.1: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Factor a quadratic expression to reveal the zeros of the function it defines. Ability to connect the factors, zeros and x-intercepts of a graph
- A.REI.4.b.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Solve quadratic equations by inspection (e.g., for  $x = 49$ ), 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 reveals that the quadratic equation has no real solutions. Ability to solve quadratic equations using various methods and recognize the most efficient method

- **FACTORING SPECIAL CASES**

- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- A.SSE.1.b.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret complicated expressions by viewing one or more of their parts as a single entity. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to quadratic and exponential expressions
- A.SSE.2.A: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to use properties of mathematics to alter the structure of an expression
- A.SSE.2.B: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to select and then use an appropriate factoring

technique

- A.SSE.1.a.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to include quadratic and exponential expressions

- **FACTORING HIGHER-ORDER POLYNOMIALS**

- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- A.SSE.2.B: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to select and then use an appropriate factoring technique
- A.APR.3.A: Expressions and Equations Understand the relationship between zeros and factors of polynomials 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. Ability to identify the zeros of a cubic polynomial of the form (linear factor)(factorable quadratic factor)

## Unit 18: Introduction to Quadratic Functions

- **QUADRATIC FUNCTIONS**

- A.SSE.1.a.1: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to make connections between symbolic representations and proper mathematics vocabulary
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- A.SSE.1.a.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to include quadratic and exponential expressions

- F.IF.4.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.BF.1.a.1: Quadratic Functions and Modeling Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. Ability to connect experience with linear and exponential functions from Unit 2 of this course to quadratic functions
- **ANALYZING GRAPHS OF QUADRATIC FUNCTIONS**
  - A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically Explain why the  $x$ -coordinates of the points where the graphs of the equations  $y = f(x)$  and  $y = (x)$  intersect are the solutions of the equation  $f(x) = (x)$ ; 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  $(x)$  are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Ability to show the equality of two functions using multiple representations
  - F.IF.9.A: Linear and Exponential Relationships Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from various representations
  - A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
  - F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
  - F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
  - F.IF.9.B: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from multiple representations
  - F.IF.8.a.2: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to recognize common attributes of a function from multiple representations

- F.IF.1.B: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to identify the domain and range of a function from multiple representations
- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
- F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
- F.IF.5.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.IF.5.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of a function based on real world context
- F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
- F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function
- F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the

changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function

- A.REI.10.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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). Ability to construct an argument as to how the points that make up a curve connect to an algebraic representation of the function that is being represented by the graph
- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.IF.4.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.BF.1.a.1: Quadratic Functions and Modeling Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. Ability to connect experience with linear and exponential functions from Unit 2 of this course to quadratic functions
- A.REI.4.b.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Solve quadratic equations by inspection (e.g., for  $x = 49$ ), 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 reveals that the quadratic equation has no real solutions. Ability to solve quadratic equations using various methods and recognize the most efficient method
- F.IF.5.C: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to recognize and use alternate vocabulary for domain and range such as input/output or independent/dependent
- A.APR.3.A: Expressions and Equations Understand the relationship between zeros and factors of polynomials 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. Ability to identify the zeros of a cubic polynomial of the form (linear factor)(factorable quadratic factor)
- **REPRESENTATIONS OF QUADRATIC FUNCTIONS**
- A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically Explain why the  $x$ -coordinates of the points where the graphs of the equations  $y = f(x)$  and  $y = (x)$  intersect are the solutions of the equation  $f(x) = (x)$ ; 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  $x$  are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Ability to show the equality of two functions using multiple representations

- A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
- F.IF.9.A: Linear and Exponential Relationships Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from various representations
- A.SSE.2.B: Expressions and Equations Interpret the structure of expressions Use the structure of an expression to identify ways to rewrite it. Ability to select and then use an appropriate factoring technique
- A.SSE.3.a.1: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Factor a quadratic expression to reveal the zeros of the function it defines. Ability to connect the factors, zeros and x-intercepts of a graph
- A.SSE.3.b.1: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. Ability to recognize key features of a quadratic model given in vertex form
- F.IF.4.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.IF.5.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to connect experiences with linear and exponential functions from

Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.

- F.IF.7.b.3: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Knowledge of how parameters introduced into a function alter the shape of the graph of the parent function
- F.IF.8.a.1: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to make connections between different algebraic representations, a graph and a contextual model
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- F.IF.9.B: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from multiple representations
- F.IF.8.a.2: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to recognize common attributes of a function from multiple representations
- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.BF.1.a.1: Quadratic Functions and Modeling Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. Ability to connect experience with linear and exponential functions from Unit 2 of this course to quadratic functions
- F.BF.1.a.2: Quadratic Functions and Modeling Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. Ability to write the algebraic representation of a quadratic function from a contextual situation

## Unit 19: Solving Quadratic Functions

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- **SOLVING QUADRATIC EQUATIONS BY FACTORING**

- A.SSE.3.a.2: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Factor a quadratic expression to reveal the zeros of the function it defines. Ability to use the Zero-Product Property to solve quadratic equations
- A.REI.4.b.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Solve quadratic equations by inspection (e.g., for  $x = 49$ ), 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 reveals that the quadratic equation has no real solutions. Ability to solve quadratic equations using various methods and recognize the most efficient method
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- F.IF.8.a.2: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to recognize common attributes of a function from multiple representations
- A.APR.3.A: Expressions and Equations Understand the relationship between zeros and factors of polynomials 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. Ability to identify the zeros of a cubic polynomial of the form (linear factor)(factorable quadratic factor)
- F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
- A.SSE.3.a.1: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Factor a quadratic expression to reveal the zeros of the function it defines. Ability to connect the factors, zeros and x-intercepts of a graph
- A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically Explain why the x-coordinates of the points where the graphs of the equations  $y = f(x)$  and  $y = (x)$  intersect are the solutions of the equation  $f(x) = (x)$ ; 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  $(x)$  are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Ability to show the equality of two functions using multiple representations

- A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- F.BF.1.a.1: Quadratic Functions and Modeling Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. Ability to connect experience with linear and exponential functions from Unit 2 of this course to quadratic functions
- **COMPLETING THE SQUARE**
  - A.REI.4.b.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Solve quadratic equations by inspection (e.g., for  $x = 49$ ), 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 reveals that the quadratic equation has no real solutions. Ability to solve quadratic equations using various methods and recognize the most efficient method
  - A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically Explain why the  $x$ -coordinates of the points where the graphs of the equations  $y = f(x)$  and  $y = (x)$  intersect are the solutions of the equation  $f(x) = (x)$ ; 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  $(x)$  are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Ability to show the equality of two functions using multiple representations
  - F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
  - A.SSE.3.b.1: Expressions and Equations Write expressions in equivalent forms to solve problems Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. Ability to recognize key features of a quadratic model given in vertex form
  - A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
  - F.IF.4.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.

- F.IF.8.a.2: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to recognize common attributes of a function from multiple representations
- F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- **QUADRATIC FORMULA**
  - A.SSE.1.a.2: Relationships between Quantities and Reasoning with Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to identify parts of an expression such as terms, factors, coefficients, etc.
  - A.SSE.1.a.1: Expressions and Equations Interpret the structure of expressions Interpret expressions that represent a quantity in terms of its context. Interpret parts of an expression, such as terms, factors, and coefficients. Ability to extend knowledge of A.SSE.1b from Unit 1 of this course to include quadratic and exponential expressions
  - F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
  - A.REI.4.b.1: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Solve quadratic equations by inspection (e.g., for  $x = 49$ ), 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 reveals that the quadratic equation has no real solutions. Ability to solve quadratic equations using various methods and recognize the most efficient method

- A.REI.4.b.2: Expressions and Equations Solve equations and inequalities in one variable Solve quadratic equations in one variable. Solve quadratic equations by inspection (e.g., for  $x = 49$ ), 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 reveals that the quadratic equation has no real solutions. Ability to use the value of the discriminant to determine if a quadratic equation has one double solution, two unique solutions or no real solutions
- A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- F.IF.8.a.2: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to recognize common attributes of a function from multiple representations
- F.BF.1.a.1: Quadratic Functions and Modeling Build a function that models a relationship between two quantities Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context. Ability to connect experience with linear and exponential functions from Unit 2 of this course to quadratic functions

## Unit 20: Graphs of Quadratic Functions

### • QUADRATIC PARENT FUNCTION

- F.IF.7.b.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Ability to make a quick sketch of each parent function over the set of real numbers
- F.IF.7.a.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph linear and quadratic functions and show intercepts, maxima, and minima. Ability to connect experience with graphing linear functions from Unit 2 of this course to include quadratic functions
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative

relationship it describes. Ability to relate the concept of domain to each function studied

- F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
- F.IF.5.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.IF.5.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of a function based on real world context
- F.IF.5.C: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to recognize and use alternate vocabulary for domain and range such as input/output or independent/dependent
- F.IF.7.b.3: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Knowledge of how parameters introduced into a function alter the shape of the graph of the parent function
- **TRANSFORMATIONS OF THE QUADRATIC PARENT FUNCTION**
  - F.IF.7.b.3: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Knowledge of how parameters introduced into a function alter the shape of the graph of the parent function
  - A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
  - F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function

- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied
- F.IF.5.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.BF.3.A: Quadratic Functions and Modeling Build new functions from existing functions Identify the effect on the graph of replacing  $f(x)$  by  $f(x) + k$ ,  $k f(x)$ ,  $f(kx)$ , 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. Ability to make generalizations about the changes that will result in the graph of any function as a result of making a particular change to the algebraic representation of the function

## Unit 21: Nonlinear Functions and Equations

### • LINEAR VERSUS NONLINEAR FUNCTIONS

- F.IF.6.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.LE.1.b.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. Ability to recognize a linear relationship
- F.LE.1.c.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. Ability to recognize an exponential relationship
- F.IF.6.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to identify the rate of change from multiple representations
- F.LE.3.A: Quadratic Functions and Modeling Construct and compare linear, quadratic, and exponential models and solve problems Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function. Ability to recognize linear, quadratic and exponential relationships
- F.LE.5.C: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to interpret the rate of increase/decrease in an exponential model

- F.IF.1.B: Linear and Exponential Relationships Understand the concept of a function and use function notation 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  $y = f(x)$ . Ability to identify the domain and range of a function from multiple representations
- F.LE.1.a.1: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems Distinguish between situations that can be modeled with linear functions and with exponential functions. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. See the skills and knowledge that are stated in the Standard.
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.IF.9.A: Linear and Exponential Relationships Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from various representations
- **SYSTEMS OF NONLINEAR EQUATIONS**
  - A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically Explain why the  $x$ -coordinates of the points where the graphs of the equations  $y = f(x)$  and  $y = (x)$  intersect are the solutions of the equation  $f(x) = (x)$ ; 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  $(x)$  are linear, polynomial, rational, absolute value, exponential, and logarithmic functions. Ability to show the equality of two functions using multiple representations
  - F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context

## Unit 22: Working with Functions

- **ABSOLUTE VALUE FUNCTIONS**

- F.IF.5.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to relate the concept of domain to each function studied

- F.IF.5.B: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of all functions based on real world context
- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- F.IF.5.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.IF.5.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. Ability to describe the restrictions on the domain of a function based on real world context
- F.IF.7.b.2: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Ability to make connections between a functions domain and range and the appearance of the graph of the function
- F.IF.4.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.
- F.IF.7.b.1: Quadratic Functions and Modeling Analyze functions using different representations Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Ability to make a quick sketch of each parent function over the set of real numbers
- **MULTIPLE REPRESENTATIONS OF FUNCTIONS**
  - A.CED.2.B: Relationships between Quantities and Reasoning with Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to determine unknown parameters needed to create an equation that accurately models a given situation

- A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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. Ability to show the equality of two functions using multiple representations
- F.IF.4.A: Linear and Exponential Relationships Interpret functions that arise in applications in terms of the context 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. Ability to translate from algebraic representations to graphic or numeric representations and identify key features using the various representations
- F.IF.9.A: Linear and Exponential Relationships Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from various representations
- F.LE.2.A: Linear and Exponential Relationships Construct and compare linear, quadratic, and exponential models and solve problems 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). Ability to produce an algebraic model
- A.CED.2.A: Expressions and Equations Create equations that describe numbers or relationships Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. Ability to distinguish between linear, quadratic and exponential relationships given numeric, or verbal representations
- F.IF.9.A: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to connect experience with comparing linear and exponential functions from Unit 2 of this course to include quadratic functions
- F.IF.9.B: Quadratic Functions and Modeling Analyze functions using different representations Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). Ability to recognize common attributes of a function from multiple representations
- A.REI.7.A: Expressions and Equations Solve systems of equations Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. Knowledge of the algebraic and graphic representations of quadratic relations as well as quadratic functions
- F.IF.4.A: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect experiences with linear and exponential functions from Unit 2 of this course to quadratic, square root, cube root, absolute value, step and piecewise defined models.

- F.IF.4.B: Quadratic Functions and Modeling Interpret functions that arise in applications in terms of the context 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. Ability to connect appropriate function to context
- F.IF.8.a.2: Quadratic Functions and Modeling Analyze functions using different representations Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 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. Ability to recognize common attributes of a function from multiple representations
- A.REI.11.A: Linear and Exponential Relationships Represent and solve equations and inequalities graphically 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. Ability to show the equality of two functions using multiple representations
- F.LE.5.B: Linear and Exponential Relationships Interpret expressions for functions in terms of the situation they model Interpret the parameters in a linear or exponential function in terms of a context. Ability to identify the initial amount present in an exponential model ( $f(0) = b + k = 1 + k$ )