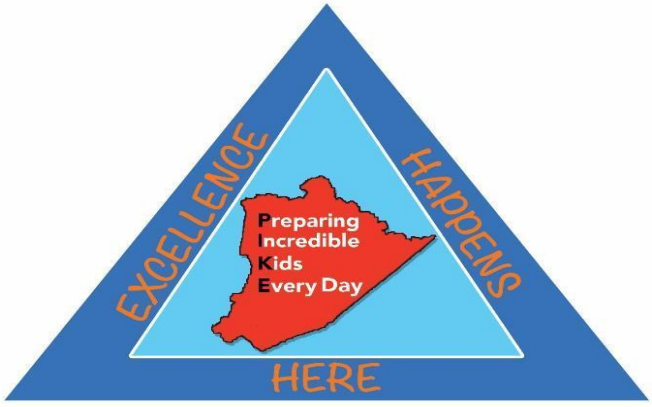
Pike County School District

Standards Mastery Document

High School Mathematics/Algebra 1
Revised 2019



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The Standards Mastery Document is designed for educators by educators as a resource and tool to help educators increase their depth of understanding of the Common Core Standards. This document will enable teachers to plan College & Career Ready curriculum and classroom instruction that promotes inquiry and higher levels of cognitive demand.

The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important "processes and proficiencies" with longstanding importance in mathematics education.

8 Mathematical Practices (MP):

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

Modeling Standards: Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Making mathematical models is a Standard for Mathematical Practice and specific modeling standards appear throughout the high school standards indicated by a star symbol (★). The star symbol sometimes appears on the heading for a group of standards; in that case, it should be understood to apply to all standards in that group.

Plus (+) Standards: Additional mathematics concepts students should learn in order to take advanced courses such as calculus, advanced statistics or discrete mathematics are indicated by (+) symbol.

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Overview

Number and Quantity Overview

The Real Number System	Quantities	The Complex Number System	Vector and Matrix Quantities
• Extend the properties of exponents to rational exponents. • Use properties of rational and irrational numbers.	• Reason quantitatively and use units to solve problems.	• Perform arithmetic operations with complex numbers. • Represent complex numbers and their operations on the complex plane. • Use complex numbers in polynomial identities and equations.	• Represent and model with vector quantities. • Perform operations on vectors. • Perform operations on matrices and use matrices in applications.

Algebra Overview

Seeing Structure in Expressions	Arithmetic with Polynomials and Rational Expressions	Creating Equations ★	Reasoning with Equations and Inequalities
• Interpret the structure of expressions. • Write expressions in equivalent forms to solve problems.	• Perform arithmetic operations on polynomials. • Understand the relationship between zeros and factors of polynomials. • Use polynomial identities to solve problems. • Rewrite rational expressions.	• Create equations that describe numbers or relationships.	• Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations. • Represent and solve equations and inequalities graphically.

Functions Overview

Interpreting Functions	Building Functions	Linear, Quadratic and Exponential Models	Trigonometric Functions
• Understand the concept of a function and use function notation. • Interpret functions that arise in applications in terms of the context. • Analyze functions using different representations.	• Build a function that models a relationship between two quantities. • Build new functions from existing functions.	• Construct and compare linear, quadratic and exponential models and solve problems. • Interpret expressions for functions in terms of the situation they model.	• Extend the domain of trigonometric functions using the unit circle. • Model periodic phenomena with trigonometric functions. • Prove and apply trigonometric identities.

Statistics and Probability Overview

Interpreting Categorical and Quantitative Data	Making Inferences and Justifying Conclusions	Conditional Probability and the Rules of Probability	Using Probability to Make Decisions
• Summarize, represent and interpret data on a single count or measurement variable. • Summarize, represent and interpret data on two categorical and quantitative variables. • Interpret linear models.	• Understand and evaluate random processes underlying statistical experiments. • Make inferences and justify conclusions from sample surveys, experiments and observational studies.	• Understand independence and conditional probability and use them to interpret data. • Use the rules of probability to compute probabilities of compound events in a uniform probability model.	• Calculate expected values and use them to solve problems. • Use probability to evaluate outcomes of decisions.

Table 1
Common Addition and Subtraction Situations1

	Result Unknown	**Change Unknown**	**Start Unknown**
Add To	Two bunnies sat on the grass. Three more bunnies hopped there. How many bunnies are on the grass now? 2+3=**?**	Two bunnies were sitting on the grass. Some more bunnies hopped there. Then there were five bunnies. How many bunnies hopped over to the first two? 2+**?**=5	Some bunnies were sitting on the grass. Three more bunnies hopped there. Then there were five bunnies. How many bunnies were on the grass before? **?**+3=5
Take From	Five apples were on the table. I ate two apples. How many apples are on the table now? 5–2=**?**	Five apples were on the table. I ate some apples. Then there were three apples. How many apples did I eat? 5-**?**=3	Some apples were on the table. I ate two apples. Then there were three apples. How many apples were on the table before? **?**–2=3
	Total Unknown	**Addend Unknown**	**Both Addends Unknown3**
Put Together/ Take Apart2	Three red apples and two green apples are on the table. How many apples are on the table? 3+2=**?**	Five apples are on the table. Three are red and the rest are green. How many apples are green? 3 + **?** = 5, 5 – 3 = **?**	Grandma has five flowers. How many can she put in her red vase and how many in her blue vase? 5 = 0 + 5, 5 = 5 + 0 5 = 1 + 4, 5 = 4 + 1 5 = 2 + 3, 5 = 3 + 2
	Difference Unknown	**Bigger Unknown**	**Smaller Unknown**
Compare	**(“How many more?” version):** Lucy has two apples. Julie has five apples. How many more apples does Lucy have than Julie?	**(Version with “more”):** Julie has three more apples than Lucy. Lucy has two apples. How many apples does Julie have?	**(Version with “more”):** Julie has three more apples than Lucy. Julie has five apples. How many apples does Lucy have?
	(“How many fewer?” version): Lucy has two apples. Julie has five apples. How many fewer apples does Lucy have than Julie? 2 + **?** = 5, 5 – 2 = **?**	(Version with “fewer”): Lucy has three fewer apples than Julie. Lucy has two apples. How many apples does Julie have? 2 + 3 = **?**, 3 + 2 = **?**	(Version with “fewer”): Lucy has three fewer apples than Julie. Julie has five apples. How many apples does Lucy have? 5 – 3 = **?**, **?** + 3 = 5

Blue shading indicates the four Kindergarten problem subtypes. Students in grades 1 and 2 work with all subtypes and variants (blue and green). Yellow indicates problems that are the difficult four problem subtypes students in grade 1 work with but do not need to master until grade 2.

1 Adapted from Box 2-4 of National Research Council (2009, op. cit., pp. 32, 33).

2These *take apart* situations can be used to show all the decompositions of a given number. The associated equations, which have the total on the left of the equal sign, help children understand that the = sign does not always mean *makes* or *results in* but always does mean *is the same number as*.

3 Either addend can be unknown, so there are three variations of these problem situations. Both Addends Unknown is a productive extension of this basic situation especially for small numbers less than or equal to 10. **4** For the Bigger Unknown or Smaller Unknown situations, one version directs the correct operation (the version using *more* for the bigger unknown and using *less* for the smaller unknown). The other versions are more difficult.

Table 2
Common Multiplication and Division Situations1

	Unknown Product	**Group Size Unknown**	**Number of Groups Unknown**
	3×6=**?**	**3 × ? = 18 and 18 ÷ 3 = ?**	**? × 6 = 18 and 18 ÷ 6 = ?**
Equal Groups	There are 3 bags with 6 plums in each bag. How many plums are there in all? Measurement example: you need 3 lengths of string, each 6 inches long. How much string will you need all together?	If 18 plums are shared equally into 3 bags, then how many plums will be in each bag? Measurement example: you have 18 inches of string which you will cut into 3 equal pieces. How long will each piece of string be?	If 18 plums are to be packed 6 to a bag, then how many bags are needed? Measurement example: you have 18 inches of string which you will cut into pieces that are 6 inches long. How many pieces of string will you have?
Arrays,2 Area3	There are three rows of apples with 6 apples in each row. How many apples are there? Area example: what is the area of a 3 cm by 6 cm triangle?	If 18 apples are arranged into 3 equal rows, how many apples will be in each row? Area example: a rectangle has area of 18 square centimeters. If one side is 3 cm long, how long is a side next to it?	If 18 apples are arranged into equal rows of 6 apples, how many rows will there be? Area example: a rectangle has area of 18 square centimeters. If one side is 6 cm long, how long is the side next to it?
Compare	A blue hat costs $6. A red hat costs 3 times as much as the blue hat. How much does the red hat cost? Measurement example: a rubber band is 6 cm long. How long will the rubber band be when it is stretched to be 3 times as long?	A red hat costs $18 and that is 3 times as much as a blue hat costs. How much does a blue hat cost? Measurement example: a rubber band is stretched to be 18 cm long and is 3 times as long as it was at first. How long was the rubber band at first?	A red hat costs $18 and a blue hat costs $6. How many times as much does the red hat cost as the blue? Measurement example: a rubber band was 6 cm long at first. Now it is stretched to be 18 cm long. How many times as long is the rubber band now as it was at first?
General	***a×b=?***	***a × ? = p and p ÷ a = ?***	***? × b =p and p ÷ b = ?***

1 The first examples in each cell are examples of discrete things. These are easier for students and should be given before the measurement examples.

[2] The language in the array examples shows the easiest form of array problems. A harder form is to use the terms rows and columns: the apples in the grocery window are in 3 rows and 6 columns. How many apples are in there? Both forms are valuable.

[3] Area involves arrays of squares that have been pushed together so that there are no gaps or overlaps, so array problems include these especially important measurement situations.

Table 3 Properties of Operations

The variables *a*, *b* and *c* stand for arbitrary numbers in a given number system.
The properties of operations apply to the rational number system, the real number system and the complex number system.

Associative property of addition	$(a + b) + c = a + (b + c)$
Commutative property of addition	$a+b=b+a$
Additive identity property of 0	a+0=0+a=a
Existence of additive inverses	For every a there exists –a so that a + (-a) = (-a) + a = 0
Associative property of multiplication	$(a \times b) \times c = a\ x\ (b \times c)$
Commutative property of multiplication	$a \times b = b \times a$
Multiplicative identity property of 1	a×1=1×a=a
Existence of multiplicative inverses	For every $a \neq 0$ there exists 1/a so that $a \times 1/a = 1/a \times a = 1$
Distributive property of multiplication over addition	$a \times (b + c) = a \times b + a \times c$

Table 4 Properties of Equality

The variables *a*, *b* and *c* stand for arbitrary numbers in the rational, real or complex number systems.

Reflexive property of equality	$a=a$
Symmetric property of equality	If$a = b$,then$b = a$
Transitive property of equality	If$a = b$and $b = c$,then a=c
Addition property of equality	If a = b, then a + c = b + c
Subtraction property of equality	If a = b, then a – c = b – c
Multiplication property of equality	If a = b, then a x c = b x c
Division property of equality	If a = b and c ≠0, then a ÷ c = b ÷ c
Substitution property of equality	If a = b, then b may be substituted for a in any expression containing a.

Table 5 Properties of Inequality

The variables *a*, *b* and *c* stand for arbitrary numbers in the rational or real number systems.

Exactly one of the following is true: a < b, a = b, a > b
If a > b and b > c then a > c
If a > b, then b < a
If a > b, then –a < -b
If a > b, then a ± c > b ± c
If a > b and c > 0, then a x c > b x c
If a > b and c < 0, then a x c < b x c
If a > b and c > 0, then a ÷ c > b ÷ c
If a > b and c < 0, then a ÷ c < b ÷ c

Table 6
Fluency Standards across All Grade Levels

Grade	Coding	Fluency Standards
K	**KY.K.OA.5**	Fluently add and subtract within 5.
1	**KY.1.OA.6**	Fluently add and subtract within 10.
2	**KY.2.OA.2 KY.2.NBT.5**	Fluently add and subtract within 20. Fluently add and subtract within 100.
3	**KY.3.OA.7 KY.3.NBT.2**	Fluently multiply and divide within 100. Fluently add and subtract within 1000.
4	**KY.4.NBT.**	Fluently add and subtract multi-digit whole numbers using an algorithm.
5	**KY.5.NBT.5**	Fluently multiply multi-digit whole numbers (not to exceed four-digit by two-digit multiplication) using an algorithm.
6	**KY.6.NS.2 KY.6.NS.3 KY.6.EE.2**	Fluently divide multi-digit numbers using an algorithm. Fluently add, subtract, multiply and divide multi-digit decimals using an algorithm for each operation. Write, read and evaluate expressions in which letters stand for numbers.

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Number and Quantity (The Real Number System) (KY.HS.N)

Standard: KY.HS.N.1 Extend the properties of integer exponents to rational exponents, allowing for the expression of radicals in terms of rational exponents.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.7 Look for and make use of structure.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can I use integer exponents to understand rational exponents? How are integer components and rational exponents related?	Define radical notation as a convention used to represent rational exponents.	Explain the properties of operations of rational exponents as an extension of the properties of integer exponents. Explain how radical notation, rational exponents, and properties of integer exponents relate to one another.

Number and Quantity (The Real Number System) (KY.HS.N)

Standard: KY.HS.N.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents.

Enduring Skills:

MP.7 Look for and make use of structure.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can I use the properties of exponents to write expressions involving radical and rational exponents?	Convert from radical representation to using rational exponents and vice versa.	Using the properties of exponents, rewrite an expression with a rational exponent. Using the properties of exponents, rewrite an expression with a rational exponent as a radical expression.

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Number and Quantity (The Real Number System) (KY.HS.N)

Standard: KY.HS.N.3 (+) Justify 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.

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of others.
MP.6 Attend to precision.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do the properties of rational and irrational numbers determine their sums and products?	Find the sums and products of rational and irrational numbers. Recognize that the sum of a rational number and an irrational number is irrational. Recognize that the product of a nonzero rational number and an irrational number is irrational.	Explain why rational numbers are closed under addition or multiplication.

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Number and Quantity (The Real Number System) (KY.HS.N)

Standard: KY.HS.N.4 Use units in context as a way to understand problems and to guide the solution of multi-step problems;

a. Choose and interpret units consistently in formulas;
b. Choose and interpret the scale and the origin in graphs and data displays.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.6 Attend to precision.

a. Choose and interpret units consistently in formulas;

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How to calculate unit conversions. Recognize units given or needed to solve the problem. Why are units important when solving problems?	Use given units and the context of a problem as a way to determine if the solution to a multi-step problem is reasonable. Choose appropriate units to represent a problem when using formulas or graphing. Interpret units or scales used in formulas or represented in graphs. Use units as a way to understand problems and to guide the solution of multi-step problems.	Students use appropriate units in calculations and in expressing solutions to real problems.

b. Choose and interpret the scale and the origin in graphs and data displays.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How to choose appropriate scales in graphs and data displays.	Interpret units or scales used in formulas or represented in graphs.	Correctly choose and interpret scales and the origin for graphs and data displays, including but not limited to: line graphs, circle graphs, histograms, multi-line graphs, scatterplots, and multi-bar graphs.

Number and Quantity (The Real Number System) (KY.HS.N)

Standard: KY.HS.N.5 Define appropriate quantities for the purpose of descriptive modeling.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.6 Attend to precision.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Define descriptive modeling.	Determine appropriate quantities for the purpose of descriptive modeling.	Determine and interpret appropriate quantities when using descriptive modeling.

Number and Quantity (The Real Number System) (KY.HS.N)

Standard: KY.HS.N.6 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.6 Attend to precision.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Identify appropriate units of measurement to report quantities. Determine the limitations of different measurement tools.	Determine the accuracy of values based on their limitations in the context of the situation.	Choose and justify a level of accuracy and/or precision appropriate to limitations on measurement when reporting quantities. Identify important quantities in a problem or real-world context.

Algebra (KY.HS.A)

Standard: KY.HS.A.1 Interpret expressions that represent a quantity in terms of its context. ★

a. Interpret parts of an expression, such as terms, factors, and coefficients.
b. Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret $P(1+r)^n$ as the product of P and a factor not depending on P.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.6 Attend to precision.

a. Interpret parts of an expression, such as terms, factors, and coefficients.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can the understanding of the parts of an expression lead to effective problem solving?	Define and recognize parts of an expression, such as terms, factors, and coefficients.	Interpret parts of an expression, such as terms, factors, and coefficients in terms of the context. Identify the different parts of the expression and explain their meaning within the context of a problem.

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

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How are terms, factors and coefficients related?	Interpret parts of an expression, such as terms, factors, and coefficients in terms of the context, by viewing one or more of their parts as a single entity.	Decompose expressions and make sense of the multiple factors and terms by explaining the meaning of the individual parts.

Algebra (KY.HS.A)

Standard: KY.HS.A.2 Use the structure of an expression to identify ways to rewrite it and consistently look for opportunities to rewrite expressions in equivalent forms.

Enduring Skills:

MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What strategies can be applied to create equivalent expressions?	Use the structure of an expression to identify ways to rewrite it. Classify expressions by structure and develop strategies to assist in classification. Identify ways to rewrite expressions, such as difference of squares, factoring out a common monomial, and regrouping. Identify various structures of expressions.	Rewrite algebraic expressions in different equivalent forms such as factoring or combining like terms. Use factoring techniques such as common factors, grouping, the difference of two squares, the sum or difference of two cubes, or a combination of methods to factor completely. Simplify expressions including combining like terms, using the distributive property and other operations with polynomials.

Algebra (KY.HS.A)

Standard KY.HS.A.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. ★

a. Write the standard form of a given polynomial and identify the terms, coefficients, degree, leading coefficient, and constant term.
b. Factor a quadratic expression to reveal the zeros of the function it defines.
c. Use the properties of exponents to rewrite exponential expressions.
d. (+) Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.

Enduring Skills:

MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

a. Write the standard form of a given polynomial and identify the terms, coefficients, degree, leading coefficient, and constant term.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Standard form of a polynomial. How to rewrite polynomial in standard form. Define terms, coefficients, degree, leading coefficient, and constant term.	Rewrite polynomials in standard form, correctly labeling parts of the expression.	Identify parts of a polynomial after rewriting in standard form.

b. Factor a quadratic expression to reveal the zeros of the function it defines.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What strategies can be used to factor a quadratic equation? How to factor a quadratic expression to produce an equivalent form of the original expression.	Choose and produce an equivalent form of a quadratic expression to reveal and explain properties of the quantity represented by the original expression. Explain the connection between the factored form of a quadratic expression and the zeros of the function it defines.	Write expressions in equivalent forms by factoring to find the zeros of a quadratic function and explain the meaning of the zeros. Given a quadratic function explain the meaning of the zeros of the function. That is if $f(x) = (x – c)(x – a)$ then $f(a) = 0$ and $f(c) = 0$. Given a quadratic expression, explain the meaning of the zeros graphically. That is for an expression $(x – a)(x – c)$, a and c correspond to the x-intercepts (if a and c are real).

c. Use the properties of exponents to transform expressions for exponential functions.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is the most efficient way to transform expressions for exponential functions? How to use the properties of exponents to transform simple expressions for exponential functions.	Choose and produce an equivalent form of a quadratic expression to reveal and explain properties of the quantity represented by the original expression.	Use properties of exponents (such as power of a power, product of powers, power of a product, and rational exponents, etc.) to write an equivalent form of an exponential function.

d. (+)Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What does completing the square in a quadratic expression reveal? Explain the connection between the completed square form of a quadratic expression and the maximum or minimum value of the function it defines. How to complete the square on a quadratic expression to produce an equivalent form of an expression.	Explain the properties of the quantity or quantities represented by the transformed exponential expression. Choose and produce an equivalent form of an exponential expression to reveal and explain properties of the quantity represented by the original expression.	Write expressions in equivalent forms by completing the square to convey the vertex form, to find the maximum or minimum value of a quadratic function, and to explain the meaning of the vertex.

Algebra (KY.HS.A)

Standard: KY.HS.A.5 Add, subtract, and multiply polynomials.

Enduring Skills:

MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Define closure. What strategies can be used to perform arithmetic operations on polynomials?	Identify that the sum, difference, or product of two polynomials will always be a polynomial, which means that polynomials are closed under the operations of addition, subtraction, and multiplication. Apply arithmetic operations of addition, subtraction, and multiplication to polynomials.	Students correctly define a polynomial. Students explain how to combine like terms under the closure property. Students explain how to multiply polynomials under the closure property. Students correctly add, subtract, and multiply polynomials.

Algebra (KY.HS.A)

Standard: KY.HS.A.16 Understand 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.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.3 Construct viable arguments and critique the reasoning of others.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the steps and strategies to justify a solution to a problem? Know that solving an equation means that the equation remains balanced during each step. Recall the properties of equality. Explain why, when solving equations, it is assumed that the original equation is equal.	Determine if an equation has a solution. Choose an appropriate method for solving the equation.	Justify solution(s) to equations by explaining each step in solving a simple equation using the properties of equality, beginning with the assumption that the original equation is equal. Construct a mathematically viable argument justifying a given, or self-generated, solution method.

Algebra (KY.HS.A)

Standard: KY.HS.A.18 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.7 Look for and make use of structure.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the rules for solving equations and inequalities?	Recall properties of equality. Solve multi-step equations in one variable. Solve multi-step inequalities in one variable.	Determine the effect that rational coefficients have on the inequality symbol and use this to find the solution set. Solve equations and inequalities with coefficients represented by letters.

Algebra (KY.HS.A)

Standard: KY.HS.A.19 Solve quadratic equations in one variable.

a. Solve quadratic equations by taking square roots, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.
b. (+) Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.
c. (+) Solve quadratic equations by completing the square.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.8 Look for and express regularity in repeated reasoning.

a. Solve quadratic equations by taking square roots, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do I determine the most appropriate and efficient strategy to use to solve quadratic equations? What are the steps and strategies to justify a solution to a problem?	Solve quadratic equations using the appropriate method. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.	Choose and justify the appropriate method for solving a quadratic equation. Recognize when the quadratic formula will yield complex solutions and write them in the form $a \pm bi$.

b. (+) Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x – p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How to complete the square.	Transform a quadratic equation written in standard form to an equation in vertex form - by completing the square. $(x – p)^2 = q$.	Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions.

c. (+) Solve quadratic equations by completing the square.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How to use completing the square to find solutions of quadratic equations.	Use completing the square to find solutions of quadratic equations.	Understand that completing the square can be used to find all real and imaginary roots of quadratic equations.

Algebra (KY.HS.A)

Standard: KY.HS.A.20 Solve systems of linear equations in two variables.

a. Understand a system of two equations in two variables has the same solution as a new system formed by replacing one of the original equations with an equivalent equation.
b. Solve systems of linear equations with graphs, substitution, and elimination, focusing on pairs of linear equations in two variables.

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of others.
MP.8 Look for and express regularity in repeated reasoning.

a. Understand a system of two equations in two variables has the same solution as a new system formed by replacing one of the original equations with an equivalent equation.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Recognize and use properties of equality to maintain equivalent systems of equations.	Use equivalent systems to find solutions of system of two equations.	Create equivalent systems to find solutions. Recognize that solutions to equivalent systems are also solutions to the original equation.

b. Solve systems of linear equations with graphs, substitution, and elimination, focusing on pairs of linear equations in two variables.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What strategy is used to solve systems of two equations?	Solve systems of equations using the elimination method (sometimes called linear combinations). Solve a system of equations by substitution (solving for one variable in the first equation and substituting it into the second equation).	Justify that replacing one equation in a two-equation system with the sum of that equation and a multiple of the other will yield the same solutions as the original system (elimination method). Students correctly solve systems of equations with two variables by substitution.

Algebra (KY.HS.A)

Standard: KY.HS.A.21 Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.7 Look for and make use of structure.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is the most efficient method to solve systems of 2 equations that include a quadratic and linear equation, algebraically and graphically?	Transform a simple system consisting of a linear equation and a quadratic equation in two variables so that a solution can be found algebraically and graphically.	Explain the correspondence between the algebraic and graphical solutions to a simple system consisting of a linear equation and a quadratic equation in two variables. Solve a system containing a linear equation and a quadratic equation in two variables (conic sections possible) graphically and symbolically.

Algebra (KY.HS.A)

Standard: KY.HS.A.23 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane.

Enduring Skills:

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

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How does a graphed solution of equations and inequalities in two variables indicate the set of all its solutions?	Recognize that the graphical representation of an equation in two variables is a curve, which may be a straight line. Understand that all solutions to an equation in two variables are contained on the graph of that equation.	Recognize that the graphical representation of an equation in two variables is a curve, which may be a straight line. Explain why each point on a curve is a solution to its equation.

Algebra (KY.HS.A)

Standard: KY.HS.A.25 Graph linear inequalities in two variables.

a. Graph the solutions to a linear inequality in as a half-plane (excluding the boundary in the case of a strict inequality).
b. Graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

Enduring Skills:

MP.5 Use appropriate tools strategically.
MP.6 Attend to precision.

a. Graph the solutions to a linear inequality in as a half-plane (excluding the boundary in the case of a strict inequality).

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How does a graphed solution of equations and inequalities in two variables indicate the set of all its solutions?	Explain the meaning of the intersection of the shaded regions in a system of linear inequalities.	Graph a line, or boundary line, and shade the appropriate region for a two variable linear inequality.

b. Graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Identify characteristics of a linear inequality and a system of linear inequalities, such as: boundary line, shading, and determine the appropriate points to test and derive a solution.	Explain the meaning of the intersection of the shaded regions in a system of linear inequalities.	Correctly graph systems of inequalities.

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Functions (KY.HS.F)

Standard: KY.HS.F.1 Understand properties and key features of functions and the different ways functions can be represented.

a. 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 functions and x is an element of it's domain, then f(x) denotes the output of f corresponding to the input x.
b. Using appropriate function notation, evaluate functions for inputs and their domains and interpret statements that use function notation in terms of context.
c. 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 feature given a verbal description of the relationship.
d. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.
e. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
MP.7 Look for and make use of structure.

a. 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 functions and x is an element of it's domain, then f(x) denotes the output of f corresponding to the input x.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Define domain and range. Understand input and output of functions.	Understand that the output value (range) depends on the input value (domain).	Understand that the output value (range) depends on the input value (domain).

b. Using appropriate function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Understand function notation.	Evaluate functions. Interpret real-world situations involving functions.	Evaluate functions for a given domain.

c. 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.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Understand when graphs are increasing, decreasing, or constant. Define, intercepts, relative maxima or minima, symmetries, end behavior, and periodicity.	Sketch the graphs of functions showing key features given a verbal description.	Sketch the graphs of functions and correctly label key features.

d. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Define domain.	Find the domain of a function in terms of its graph.	Relate to domain to the graph of a function and the quantitative relationship it describes.

e. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Various types of function representations.	Compare characteristics from various representations of functions.	Compare characteristics from various representations of functions.

Functions (KY.HS.F)

Standard: KY.HS.F.2 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers.

Enduring Skills:

MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is a function, how is it written and interpreted?	Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers.	Recognize that sequences, sometimes defined recursively, are functions whose domain is a subset of the set of integers.

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Functions (KY.HS.F)

Standard: KY.HS.F.3 Understand average rate of change of a function over an interval.

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

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

a. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is the average rate of change?	Recognize slope as an average rate of change. Calculate 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 linear or exponential graph.	Correctly calculate the average rate of change of a function (presented symbolically or as a table) over a specified interval.

b. Estimate the rate of change from a graph

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is the average rate of change?	Estimate the rate of change from a linear or exponential graph.	Correctly calculate the average rate of change of a function (presented symbolically or as a table) over a specified interval.

Functions (KY.HS.F)

Standard: KY.HS.F.4 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

a. Graph linear and quadratic functions and show intercepts, maxima, and minima.
b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.
c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.
d. Graph exponential and logarithmic functions, showing intercepts and end behavior and trigonometric functions, showing period, midline, and amplitude.
e. (+) Graph trigonometric functions, including step functions.
f. (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available and showing end behavior.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
MP.5 Use appropriate tools strategically.
MP.6 Attend to precision.

a. Graph linear and quadratic functions and show intercepts, maxima, and minima.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the differences between linear and quadratic graphs? Define intercepts, maxima, and minima.	Graph linear functions. Graph quadratic functions. Label intercepts, maxima, and minima.	Correctly graph linear and quadratic functions and understand the difference in their graphs, domain, and range. Correctly label intercepts, maxima, and minima.

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

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What essential information is indicated when graphing square root, cube root and piecewise-defined functions?	Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions, by hand in simple cases or using technology for more complicated cases, and show/label key features of the graph.	Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.

c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What essential information is indicated when graphing polynomial functions?	Graph polynomial functions, by hand in simple cases or using technology for more complicated cases, and show/label maxima and minima of the graph, identify zeros when suitable factorizations are available, and show end behavior.	Determine the difference between simple and complicated polynomial functions. Relate the relationship between zeros of quadratic functions and their factored forms to the relationship between polynomial functions of degrees greater than two.

d. Graph exponential and logarithmic functions, showing intercepts and end behavior and trigonometric functions, showing period, midline, and amplitude.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What essential information is indicated when graphing exponential, logarithmic, and trigonometric functions?	Graph exponential, logarithmic, and trigonometric functions, by hand in simple cases or using technology for more complicated cases, and show/label maxima and minima of the graph, identify zeros when suitable factorizations are available, and show end behavior.	Determine the difference between simple and complicated exponential, logarithmic, and trigonometric functions. Graph exponential, logarithmic, and trigonometric functions.

e. (+) Graph trigonometric functions, including step functions.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What essential information is indicated when graphing trigonometric functions?	Graph trigonometric functions.	Graph trigonometric functions, by hand in simple cases or using technology for more complicated cases, and show/label maxima and minima of the graph, identify zeros when suitable factorizations are available, and show end behavior.

f. (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available and showing end behavior.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What essential information is indicated when graphing rational functions?	Graph rational functions. Label key features, including end behavior.	Graph rational functions, by hand in simple cases or using technology for more complicated cases, and show/label maxima and minima of the graph, identify zeros when suitable factorizations are available, and show end behavior.

Functions (KY.HS.F)

Standard: KY.HS.F.5 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

a. Identify zeros, extreme values, and symmetry of the graph within the context of a quadratic function.
b. Use the properties of exponents to interpret expressions for exponential functions and classify the exponential function as representing growth or decay.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
MP.5 Use appropriate tools strategically.
MP.6 Attend to precision.
MP.7 Look for and make use of structure.

a. Identify zeros, extreme values, and symmetry of the graph within the context of a quadratic function.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can a quadratic function be interpreted when factoring and completing the square? Define zeros, extreme values, and symmetry.	Identify different forms of a quadratic expression. Identify zeros, extreme values, and symmetry of the graph of a quadratic function. Identify how key features of a quadratic function relate to its characteristics in a real-world context. Write functions in equivalent forms using the process of factoring.	Interpret different yet equivalent forms of a function defined by an expression in terms of a context. Given the expression of a quadratic function, interpret zeros, extreme values, and symmetry of the graph in terms of a real-world context. 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.

b. Use the properties of exponents to interpret expressions for exponential functions and classify the exponential function as representing growth or decay.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can multiple representations of functions help reveal and explain different properties of the function? Classify the exponential function as exponential growth or decay by examining the base. Identify how key features of an exponential function relate to its characteristics in a real-world context.	Use the properties of exponents to interpret expressions for exponential functions in a real world context. Given the expression of an exponential function, interpret the expression in terms of a real-world context, using the properties of exponents.	Write an exponential function defined by an expression in different but equivalent forms to reveal and explain different properties of the function, and determine which form of the function is the most appropriate for interpretation in a real-world context. Write a quadratic function defined by an expression in different but equivalent forms to reveal and explain different properties of the function and determine which form of the quadratic is the most appropriate for showing zeros and symmetry of a graph in terms of a real-world context.

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Functions (KY.HS.F)

Standard: KY.HS.F.6 Write a function that describes a relationship between two quantities. ★

a. Determine an explicit expression, a recursive process, or steps for calculation from a context.
b. Combine standard function types using arithmetic operations.
c. (+) Compose functions.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

a. Determine an explicit expression, a recursive process, or steps for calculation from a context.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
Define explicit function and recursive process.	From context, either write an explicit expression, define a recursive process, or describe the calculations needed to model a function between two quantities.	Write a function that describes a relationship between two quantities by determining an explicit expression, a recursive process, or steps for calculation from a context.

b. Combine standard function types using arithmetic operations.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What strategy can be used to write a function that describes a relationship between two quantities?	Combine two functions using the operations of addition, subtraction, multiplication, and division. Evaluate the domain of the combined function. Combine standard function types, such as linear and exponential, using arithmetic operations.	Given a real-world situation or mathematical problem, build standard functions to represent relevant relationships/ quantities. Given a real-world situation or mathematical problem, determine which arithmetic operation should be performed to build the appropriate combined function.

c. (+) Compose functions.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How to compose functions.	Compose functions.	Compose functions and state the domain.

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Functions (KY.HS.F)

Standard: KY.HS.F.7 Use arithmetic and geometric sequences to model situations and scenarios.

a. Use formulas (explicit and recursive) to generate terms for arithmetic and geometric sequences.
b. Write formulas to model arithmetic and geometric sequences and apply those formulas in realistic situations. ★
c. (+) Translate between recursive and explicit formulas.

Enduring Skills:

MP.4 Model with mathematics.
MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

a. Use formulas (explicit and recursive) to generate terms for arithmetic and geometric sequences.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the differences between arithmetic and geometric sequences? Explicit and recursive formulas.	Identify arithmetic and geometric patterns in given sequences. Generate arithmetic and geometric sequences from recursive and explicit formulas. Given an arithmetic or geometric sequence in recursive form, translate into the explicit formula. Given an arithmetic or geometric sequence as an explicit formula, translate into the recursive form.	Determine the recursive rule given arithmetic and geometric sequences. Determine the explicit formula given arithmetic and geometric sequences. Justify the translation between the recursive form and explicit formula for arithmetic and geometric sequences.

b. Write formulas to model arithmetic and geometric sequences and apply those formulas in realistic situations. ★

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What arithmetic and geometric sequences can be used to model situations?	Identify arithmetic and geometric patterns in given sequences. Generate arithmetic and geometric sequences from recursive and explicit formulas.	Use given and constructed arithmetic and geometric sequences, expressed both recursively and with explicit formulas, to model real-life situations.

c. (+) Translate between recursive and explicit formulas.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the differences between arithmetic and geometric sequences? Explicit and recursive formulas.	Given an arithmetic or geometric sequence in recursive form, translate into the explicit formula. Given an arithmetic or geometric sequence as an explicit formula, translate into the recursive form.	Justify the translation between the recursive form and explicit formula for arithmetic and geometric sequences.

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Functions (KY.HS.F)

Standard: KY.HS.F.8 Understand the effects of transformations on the graph of a function.

a. 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.
b. Experiment with cases and illustrate an explanation of the effects on the graph using technology.

Enduring Skills:

MP.4 Model with mathematics.
MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

a. 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.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How does a graphed function changed when values are replaced (both positive and negative)?	Given a single transformation on a symbolic or graphic function, identify the effect on the graph. Graph a given function by 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).	Describe the differences and similarities between a parent function and the transformed function. Find the value of k, given the graphs of a parent function, *f(x),* and the transformed function: *f(x) + k, k f(x), f(kx),* or *f(x + k).* Recognize even and odd functions from their graphs and equations.

b. Experiment with cases and illustrate an explanation of the effects on the graph using technology.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How does a graphed function changed when values are replaced (both positive and negative)?	Using technology, identify effects of single transformations on graphs of functions.	Experiment with cases and illustrate an explanation of the effects on the graph, using technology.

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Functions (KY.HS.F)

Standard: KY.HS.F.9 Find inverse functions.

a. Given the equation of an invertible function, find the inverse.
b. (+) Verify by composition that one function is the inverse of another.
c. (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.
d. (+) Produce an invertible function from a non-invertible function by restricting the domain.

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of others.
MP.4 Model with mathematics.
MP.7 Look for and make use of structure.

a. Given the equation of an invertible function, find the inverse.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What method can be used to develop and define inverse functions? Define inverse function. Define invertible function.	Define inverse function. Solve and equation f(x)=c for a simple function, f, that has an inverse and write an expression for the inverse.	Solve a function for the dependent variable and write the inverse of a function by interchanging the values of the dependent and independent variables. Recognize when a function is invertible.

b. (+) Verify by composition that one function is the inverse of another.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can we use composition of functions to verify inverses?	Use composition of functions to prove that one function is the inverse of another.	Correctly verify inverse functions using composition.

c. (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How are functions and their inverses related?	Describe the relationship between a function and it's inverse.	Understand a function and its inverse describe the exact same relationship, but in different ways.

d. (+) Produce an invertible function from a non-invertible function by restricting the domain.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How can we manipulate the domain to produce invertible functions?	Place restrictions on the domain that will produce invertible functions from non-invertible functions.	Correctly place restrictions on the domain that will produce invertible functions from non-invertible functions.

Functions (KY.HS.F)

Standard: KY.HS.F.11 Distinguish between situations that can be modeled with linear functions and with exponential functions.

a. Recognize and justify that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.
b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.
c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of others.
MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do I determine the situations that can be modeled with linear and exponential functions? How do I prove the equal factor growth of linear and exponential functions?	Recognize that linear functions grow by equal differences over equal intervals. Recognize that exponential functions grow by equal factors over equal intervals. Show that linear functions change at the same rate over time and that exponential functions change by equal factors over time.	Distinguish between situations that can be modeled with linear functions and exponential functions to solve mathematical and real-world problems. Prove that linear functions grow by equal differences over equal intervals. Prove that exponential functions grow by equal factors over equal intervals.

b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do I determine the situations that can be modeled with linear and exponential functions?	Recognize situations in which one quantity changes at a constant rate per unit (equal distances), relative to another to solve mathematical and real-world problems.	Describe situations where one quantity changes at a constant rate per unit interval as compared to another.

c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do I determine the situations that can be modeled with linear and exponential functions?	Recognize situations in which a quantity grows or decays by a constant percent rate per unit (equal factors), relative to another to solve mathematical and real-world problems.	Describe situations where a quantity grows or decays at a constant percent rate per unit interval as compared to another.

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Functions (KY.HS.F)

Standard: KY.HS.F.11 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.)

Enduring Skills:

MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the strategies and methods used to construct and compare linear, quadratic and exponential models and solve problems?	Recognize that arithmetic sequences can be expressed as linear functions. Recognize that geometric sequences can be expressed as exponential functions. Construct linear functions, including arithmetic sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). Construct exponential functions, including geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).	Create linear and exponential functions given the following situations: ➢ arithmetic and geometric sequences. ➢ a graph. ➢ a description of a relationship. ➢ two points, which can be read from a table . Determine when a graph, a description of a relationship, or two input-output pairs (include reading these from a table) represents a linear or exponential function in order to solve problems.

Functions (KY.HS.F)

Standard: KY.HS.F.13 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.

Enduring Skills:

MP.7 Look for and make use of structure.
MP.8 Look for and express regularity in repeated reasoning.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the strategies and methods used to construct and compare linear, quadratic and exponential models and solve problems?	Fluently compute growth rates for linear, exponential, and quadratic functions. Compare tables and graphs of exponential and other polynomial functions to observe that a quantity, increasing exponentially, exceeds all others to solve mathematical and real-world problems.	Make the connection, using graphs and tables, that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or any other polynomial function.

Functions (KY.HS.F)

Standard: KY.HS.F.14 Interpret the parameters in a linear or exponential function in terms of a context.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.2 Reason abstractly and quantitatively.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What are the strategies and methods used to construct and compare linear, quadratic and exponential models and solve problems?	Recognize linear or exponential function including: vertical and horizontal shifts, vertical and horizontal dilations. Recognize rates of change and intercepts as parameters in linear or exponential functions.	Interpret the parameters in a linear or exponential function in terms of a context. Based on the context of a situation, explain the meaning of the coefficients, factors, exponents, and/or intercepts in a linear or exponential function.

Probability and Statistics (KY.HS.SP)

Standard KY.HS.SP.1 Represent the distribution of data with plots on the real number line (stem plots, dot plots, histograms, and box plots).

Enduring Skills:

MP.4 Model with mathematics.
MP.5 Use appropriate tools strategically.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do various representations of data lead to different interpretations of data?	Summarize, represent, and interpret data on a single count or measurement variable.	Represent data with plots on the real number line, using various display types by creating stem plots, dot plots, histograms, and box plots.

Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.2 Use statistics appropriate to the shape of the numerical data distribution to compare center (median, mean) and spread (interquartile range when comparing medians and standard deviation when comparing means) of different data distributions.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.6 Attend to precision.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How do various representations of data lead to different interpretations of data?	Choose the appropriate measure for center (mean, median) and spread (interquartile range, standard deviation) based on the shape of a data distribution. Use appropriate statistics for center and spread to compare two or more data sets.	Describe a distribution center and spread. Use the correct measure center and spread to describe a distribution that is symmetric or skewed. Identify outliers (extreme data points) and their effects on data sets. Compare two or more different data sets using the center and spread of each.

Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.3 Interpret differences in shape, center, and spread in the context of the distributions of the numerical data, accounting for the presence possible effects of extreme data points (outliers).

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.
MP.7 Look for and make use of structure.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
When and how can extreme data point's impact interpretation and be compared?	Interpret differences in different data sets in context. Interpret differences due to possible effects of outliers.	Interpret differences in shape, center, and spread in the context of data sets. Describe the possible effects the presence of outliers in a set of data can have on shape, center, and spread in the context of the data sets.

Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.5 Summarize categorical data for two or more categories in frequency tables. Calculate and interpret joint, marginal, and conditional relative frequencies (probabilities) in the context of the data, recognizing possible associations and trends in the data.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
MP.7 Look for and make use of structure.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How is a data set represented in a two-way frequency table summarized?	Create a two-way table from two categorical variables and read values from two way table. Interpret joint, marginal, and relative frequencies in context. Recognize associations and trends in data from a two-way table.	Interpret relative frequencies in the context of the data. Recognize possible associations and trends in the data.

Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.6 Represent data on two quantitative variables on a scatter plot, and describe how the explanatory and response variables are related.

a. Calculate an appropriate mathematical model, or use a given mathematical model, for data to solve problems in context.
b. Informally assess the fit of a model (through calculating correlation for linear data, plotting, calculating and/or analyzing residuals).

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of others.
MP.4 Model with mathematics.
MP.5 Use appropriate tools strategically.

a. Calculate an appropriate mathematical model, or use a given mathematical model, for data to solve problems in context.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
How does a function fitted to data help solve problems?	Represent data on a scatter plot (2 quantitative variables). Choose appropriate mathematical models.	Using given scatter plot data represented on the coordinate plane, informally describe how the two quantitative variables are related. Determine which function best models scatter plot data represented on the coordinate plane, and describe how the two quantitative variables are related. Use functions fitted to data to solve problems in the context of the data.

b. Informally assess the fit of a model (through calculating correlation for linear data, plotting, calculating and/or analyzing residuals).

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What strategy can be used to assess the fit of a graphed function?	Fit a given function class (e.g. linear, exponential) to a data set.	Represent the residuals from a function and the data set it models, numerically and graphically. Informally assess the fit of a function by analyzing residuals from the residual plot.

Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

Enduring Skills:

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

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What information is needed to interpret linear models?	Explain the meaning of the slope and y-intercept in context.	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

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Algebra 1

Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.8 Understand the role and purpose of correlation in linear regression.

a. Use technology to compute correlation of a linear fit.
b. Interpret the meaning of the correlation within the context of the data.
c. Describe the limitations and correlation when establishing causation.

Enduring Skills:

MP.2 Reason and abstractly and quantitatively.
MP.3 Construct viable arguments and critique the reasoning of others.
MP.5 Use appropriate tools strategically.

a. Use technology to compute correlation of a linear fit.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is the most efficient way to determine the correlation coefficient of a linear fit? Define the correlation coefficient.	Use a calculator or computer to find the correlation for a linear association.	Interpret the correlation coefficient of a linear fit as a measure of how well the data fit the relationship.

b. Interpret the meaning of the correlation within the context of the data.

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What is the most efficient way to determine the correlation coefficient of a linear fit? Define the correlation coefficient.	Interpret the meaning of the value in the context of the data.	Interpret the correlation coefficient of a linear fit as a measure of how well the data fit the relationship.

c. Describe the limitations and correlation when establishing causation

Know: *What content does the student need to know to demonstrate this standard?*	**Do:** *What skill must the student demonstrate?*	**Mastery:** *How does the student demonstrate the learning of the standard?*
What strategy can be used to distinguish between correlation and causation?	Define causation. Define positive, negative, and no correlation and explain why correlation does not imply causation.	Distinguish between correlation and causation.

Table 1

Common Addition and Subtraction Situations[1]

	Result Unknown	**Change Unknown**	**Start Unknown**
Add To	Two bunnies sat on the grass. Three more bunnies hopped there. How many bunnies are on the grass now? 2 + 3 = ?	Two bunnies were sitting on the grass. Some more bunnies hopped there. Then there were five bunnies. How many bunnies hopped over to the first two? 2 + ? = 5	Some bunnies were sitting on the grass. Three more bunnies hopped there. Then there were five bunnies. How many bunnies were on the grass before? ? + 3 = 5
Take From	Five apples were on the table. I ate two apples. How many apples are on the table now? 5 – 2 = ?	Five apples were on the table. I ate some apples. Then there were three apples. How many apples did I eat? 5 - ? = 3	Some apples were on the table. I ate two apples. Then there were three apples. How many apples were on the table before? ? – 2 = 3
	Total Unknown	**Addend Unknown**	**Both Addends Unknown**[3]
Put Together/ Take Apart[2]	Three red apples and two green apples are on the table. How many apples are on the table? 3 + 2 = ?	Five apples are on the table. Three are red and the rest are green. How many apples are green? 3 + ? = 5, 5 – 3 = ?	Grandma has five flowers. How many can she put in her red vase and how many in her blue vase? 5 = 0 + 5, 5 = 5 + 0 5 = 1 + 4, 5 = 4 + 1 5 = 2 + 3, 5 = 3 + 2
	Difference Unknown	**Bigger Unknown**	**Smaller Unknown**
Compare[4]	**("How many more?" version):** Lucy has two apples. Julie has five apples. How many more apples does Lucy have than Julie? **("How many fewer?" version):** Lucy has two apples. Julie has five apples. How many fewer apples does Lucy have than Julie? 2 + ? = 5, 5 – 2 = ?	**(Version with "more"):** Julie has three more apples than Lucy. Lucy has two apples. How many apples does Julie have? **(Version with "fewer"):** Lucy has three fewer apples than Julie. Lucy has two apples. How many apples does Julie have? 2 + 3 = ?, 3 + 2 = ?	**(Version with "more"):** Julie has three more apples than Lucy. Julie has five apples. How many apples does Lucy have? **(Version with "fewer"):** Lucy has three fewer apples than Julie. Julie has five apples. How many apples does Lucy have? 5 – 3 = ?, ? + 3 = 5

Blue shading indicates the four Kindergarten problem subtypes. Students in grades 1 and 2 work with all subtypes and variants (blue and green). Yellow indicates problems that are the difficult four problem subtypes students in grade 1 work with but do not need to master until grade 2.

[1] Adapted from Box 2-4 of National Research Council (2009, op. cit., pp. 32, 33).

[2] These *take apart* situations can be used to show all the decompositions of a given number. The associated equations, which have the total on the left of the equal sign, help children understand that the = sign does not always mean *makes* or *results in* but always does mean *is the same number as*.

[3] Either addend can be unknown, so there are three variations of these problem situations. Both Addends Unknown is a productive extension of this basic situation especially for small numbers less than or equal to 10.

[4] For the Bigger Unknown or Smaller Unknown situations, one version directs the correct operation (the version using *more* for the bigger unknown and using *less* for the smaller unknown). The other versions are more difficult.

Table 6
Fluency Standards across All Grade Levels

Coding	Fluency Standards
KY.K.OA.5	Fluently add and subtract within 5.
KY.1.OA.6	Fluently add and subtract within 10.
KY.2.OA.2 KY.2.NBT.5	Fluently add and subtract within 20. Fluently add and subtract within 100.
KY.3.OA.7 KY.3.NBT.2	Fluently multiply and divide within 100. Fluently add and subtract within 1000.
KY.4.NBT.	Fluently add and subtract multi-digit whole numbers using an algorithm.
KY.5.NBT.5	Fluently multiply multi-digit whole numbers (not to exceed four-digit by two-digit multiplication) using an algorithm.
KY.6.NS.2 KY.6.NS.3 KY.6.EE.2	Fluently divide multi-digit numbers using an algorithm. Fluently add, subtract, multiply and divide multi-digit decimals using an algorithm for each operation. Write, read and evaluate expressions in which letters stand for numbers.
KY.7.NS.1d KY.7.NS.2c	Apply properties of operations as strategies to add and subtract rational numbers. Apply properties of operations as strategies to multiply and divide rational numbers.
KY.8.EE.7	Solve linear equations in one variable.
KY.HS.A.2 KY.HS.A.19	Use the structure of an expression to identify ways to rewrite it and consistently look for opportunities to rewrite expressions in equivalent forms. Solve quadratic equations in one variable.
KY.HS.F.4 KY.HS.F.8	Graph functions expressed symbolically and show key features of the graph both with and without technology (i.e., computer, graphing calculator).★ Understand the effects of transformations on the graph of a function.
KY.HS.G.21 KY.HS.G.11c KY.HS.G.12c	Use coordinates to justify and prove simple geometric theorems algebraically. Use similarity criteria for triangles to solve problems in geometric figures. Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.★