

***Pike County School District
Standards Mastery Document***

High School Mathematics/Algebra 2
Revised 2019



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Standards Mastery Document - Revised 2019
High School Algebra 2

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
<ul style="list-style-type: none"> Extend the properties of exponents to rational exponents. Use properties of rational and irrational numbers. 	<ul style="list-style-type: none"> Reason quantitatively and use units to solve problems. 	<ul style="list-style-type: none"> Perform arithmetic operations with complex numbers. Represent complex numbers and their operations on the complex plane. Use complex numbers in polynomial identities and equations. 	<ul style="list-style-type: none"> 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
<ul style="list-style-type: none"> Interpret the structure of expressions. Write expressions in equivalent forms to solve problems. 	<ul style="list-style-type: none"> Perform arithmetic operations on polynomials. Understand the relationship between zeros and factors of polynomials. Use polynomial identities to solve problems. Rewrite rational expressions. 	<ul style="list-style-type: none"> Create equations that describe numbers or relationships. 	<ul style="list-style-type: none"> 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
<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Build a function that models a relationship between two quantities. Build new functions from existing functions. 	<ul style="list-style-type: none"> Construct and compare linear, quadratic and exponential models and solve problems. Interpret expressions for functions in terms of the situation they model. 	<ul style="list-style-type: none"> 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
<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Understand and evaluate random processes underlying statistical experiments. Make inferences and justify conclusions from sample surveys, experiments and observational studies. 	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Calculate expected values and use them to solve problems. Use probability to evaluate outcomes of decisions.

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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 Unknown ³
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).

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.

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Table 2
Common Multiplication and Division Situations¹

	Unknown Product	Group Size Unknown	Number of Groups Unknown
	$3 \times 6 = ?$	$3 \times ? = 18$ and $18 \div 3 = ?$	$? \times 6 = 18$ and $18 \div 6 = ?$
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	$a \times b = ?$	$a \times ? = p$ and $p \div a = ?$	$? \times b = p$ and $p \div b = ?$

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.

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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	$(a \times b) \times c = a \times (b \times c)$
Commutative property of multiplication	$a \times b = b \times a$
Multiplicative identity property of 1	$a \times 1 = 1 \times a = a$
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 $a \times c = b \times c$
Division property of equality	If $a = b$ and $c \neq 0$, then $a \div c = b \div c$
Substitution property of equality	If $a = b$, then b may be substituted for a in any expression containing a .

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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 $a \pm c > b \pm c$
If $a > b$ and $c > 0$, then $a \times c > b \times c$
If $a > b$ and $c < 0$, then $a \times c < b \times c$
If $a > b$ and $c > 0$, then $a \div c > b \div c$
If $a > b$ and $c < 0$, then $a \div c < b \div c$

**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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The Complex Number System (KY.HS.N)

Standard: KY.HS.N.7 Understanding properties of complex numbers.

- a. Know there is a complex number i such that $i^2 = -1$ and every complex number has the form $a + bi$ with a and b real.
- b. Use the relation $i^2 = -1$ and the commutative, associative and distributive properties to add, subtract and multiply complex numbers.
- c. (+) Find the conjugate of a complex number and use it to find the quotient of complex numbers

Enduring Skills:

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

- a. Know there is a complex number i such that $i^2 = -1$ and every complex number has the form $a + bi$ with a and b real.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
What are real vs. imaginary numbers?	Identify real vs. imaginary parts of complex number.	Students correctly identify numbers as real or imaginary; real or complex.
What is i ?		
Standard form of complex number		

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b. Use the relation $i^2 = -1$ and the commutative, associative and distributive properties to add, subtract and multiply complex numbers.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How do you perform basic operations on complex numbers?</p> <p>How do the properties of real numbers apply to complex numbers?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Add, subtract, and multiply complex numbers.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly perform basic operations on complex numbers while applying the relation $i^2 = -1$ and properties of real numbers.</p>
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c. (+) Find the conjugate of a complex number and use it to find the quotient of complex numbers

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Understand complex conjugates.</p> <p>How can complex conjugates be used to find the quotient of complex numbers?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Find the complex conjugate of a complex number.</p> <p>Use complex conjugates to find quotients of complex numbers.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Understand the complex as the pair of binomial complex factors, $(a+bi)(a-bi)$, whose product is a difference of squares, which is a real number.</p> <p>Understand that the denominator of a fraction can be resolved of an imaginary number by multiplying both the numerator and denominator by the conjugate of the denominator.</p>
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The Complex Number System (KY.HS.N)

Standard: KY.HS.N.8 (+) Understanding representations of complex numbers using the complex plane.

Enduring Skills:

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How can we visually represent complex numbers in the complex plane?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Graph complex numbers in the complex plane.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly label the complex plane.</p> <p>Correctly graph complex numbers.</p>
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The Complex Number System (KY.HS.N)

Standard: KY.HS.N.9 Solve quadratic equations with real coefficients that have complex solutions.

Enduring Skills:

- MP.2 Reason abstractly and quantitatively.
- MP.5 Use appropriate tools strategically.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>What is a quadratic equation?</p> <p>What does it mean for a quadratic equation to have complex solutions?</p> <p>How to find solutions of a quadratic equation using the quadratic formula or completing the square.</p>	<p>Solve quadratic equations using the quadratic formula.</p> <p>Simplify the results of the quadratic formula when there is a negative discriminant.</p> <p>Solve quadratic equations by completing the square.</p>	<p>Students correctly explain when quadratic equations have complex versus real solutions.</p> <p>Students correctly solve quadratic equations using the quadratic formula or completing the square when there are complex solutions.</p>

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The Complex Number System (N.CN)

Standard: KY.HS.N.10 (+) Extend polynomial identities to the complex numbers.

Enduring Skills:

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>What are the polynomial identities?</p> <p>How do polynomial identities apply to complex numbers?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Simplify polynomials involving complex numbers.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Recognize and understand the value of $i^2 = -1$ and fluently simplify each polynomial appropriately navigating between the real number system and complex numbers.</p>
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The Complex Number System (KY.HS.N)

Standard: KY.HS.N. 11 (+) Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.

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: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
What is the Fundamental Theorem of Algebra?	Use the degree of a polynomial to find the number of possible real and complex roots.	Use the Fundamental Theorem of Algebra to find the number of possible roots of quadratic polynomials.

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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, given a context, by viewing one or more of their parts as a single entity.

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.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How can the understanding of the parts of an expression lead to effective problem solving?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Define and recognize parts of an expression, such as terms, factors, and coefficients.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Interpret parts of an expression, such as terms, factors, and coefficients in terms of context.</p> <p>Identify the different parts of the expression and explain their meaning within the context of a problem.</p>
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- b. Interpret complicated expressions, given a context, by viewing one or more of their parts as a single entity.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How are terms, factors, and coefficients related?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Understand the vocabulary for the parts that make up the whole expression and be able to identify those parts.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Decompose expressions and make sense of multiple factors and terms by explaining the meaning of the individual parts.</p>
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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: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
What strategies can be applied to create equivalent expressions?	<p>Use the structure of an expression to identify ways to rewrite it.</p> <p>Classify expressions by structure and develop strategies to assist in classification.</p> <p>Identify ways to rewrite expressions, such as difference of squares, factoring out a common monomial, and regrouping.</p> <p>Identify various structures of expressions.</p>	<p>Rewrite algebraic expressions in different forms such as factoring and combining like terms.</p> <p>Use factoring techniques such as common factors, grouping, the difference of two squares, the sum or difference of cubes, or a combination of methods to factor completely.</p> <p>Simplify expressions including combining like terms, using the distributive property and other operations with polynomials.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.4 (+) Derive the formula for the sum of a finite geometric series (when the common ratio is not 1) and use the formula to solve problems. ★

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Define a geometric series as a series with a constant ratio between successive terms.</p> <p>Use the formula $S+a(1-rn)/(1-r)$ to solve problems.</p>	<p>Develop the formula for the sum of a finite geometric series using $S+a(1-rn)/(1-r)$.</p> <p>Use the formula to solve real world problems given initial values and the rate of change.</p>	<p>Student correctly use the formula $S+a(1-rn)/(1-r)$ to find the sum of a finite geometric series.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.5 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.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Understand the definition of a polynomial.	Simplify polynomials by combining like terms.	Students correctly simplify polynomials by combining like terms.
Understand the concepts of combining like terms and closure.	Add and subtract polynomial expressions.	Students write polynomials in simplest form and in correct order.
Understand how closure applies to adding, subtracting, and multiplying polynomials.	Multiply polynomial expressions.	Students correctly combine polynomials using addition, subtraction, and multiplication. Polynomials should be simplified.

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Algebra (KY.HS.A)

Standard: KY.HS.A.6 (+) Know and apply the Remainder Theorem.

Enduring Skills:

MP.1 Make sense of problems and persevere in solving them.

MP.8 Look for and express regularity in repeated reasoning.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Understand and apply the Remainder Theorem for polynomials.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Determine if a is a root of a polynomial using the Remainder Theorem.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Students use the Remainder Theorem to correctly identify roots of a polynomial.</p>
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Algebra (KY.HS.A)

Standard: KY.HS.A.7 Identify roots of polynomials when suitable factorizations are available. Know these roots become the zeros (x-intercepts) for the corresponding polynomial function.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.

MP.5 Use appropriate tools strategically.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
What is the relationship between x-intercepts, roots, and factors?	Factor polynomials using any method or a combination of methods.	Students correctly factor polynomial expressions using the best available method or a combination of method.
How to find the zeros of a polynomial function when the polynomial is in factored form.	Use the x-intercepts to sketch the graph of a polynomial.	Students use the x-intercepts of a polynomial to sketch a graph of the function (students will use substitution to find points between the x-intercepts).
How to use the zeros of a polynomial to sketch the graph of a function.		

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Algebra (KY.HS.A)

Standard: KY.HS.A.8(+) Prove polynomial identities and use them to describe numerical relationships.

Enduring Skill:

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of other.

MP.6 Attend to precision.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Understand that polynomial identities include but are not limited to the product of the sum and difference of two terms, the difference of two squares, the sum and difference of two cubes, the square of a binomial, etc.	<p>Explain that an identity shows a relationship between two quantities or expressions, which is true for all values of the variables.</p> <p>Prove polynomial identities.</p>	<p>Students can prove polynomials identities by showing steps and providing reasons.</p> <p>Students can use polynomial identities to describe numerical relationships.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.9 (+) Know and apply the Binomial Theorem for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n , where x and y are any numbers, with coefficients determined for example by Pascal’s Triangle.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Define the Binomial Theorem.</p> <p>Compute combinations using the binomial theorem.</p> <p>How to find the nth term of in the expansion of a binomial.</p>	<p>Use Pascal’s Triangle to determine the coefficients of a binomial expansion.</p> <p>Use the Binomial Theorem to find the nth term in a binomial expansion to a positive power.</p>	<p>Students correctly apply Pascal’s Triangle to determine the coefficients of a binomial expansion.</p> <p>Students correctly identify the nth terms in a binomial expansion using the Binomial Theorem.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.10(+) Rewrite simple rational expressions in different forms.

Enduring Skills:

MP.5 Use appropriate tools strategically.

MP.7 Look for and make use of structure.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
How to rewrite rational expressions using factoring, long division, or synthetic division.	<p>Rewrite simple rational expressions in different forms using factoring or synthetic division.</p> <p>Use computer algebra systems to rewrite complicated rational expressions in different forms.</p>	<p>Students correctly rewrite simple rational expressions.</p> <p>Students correctly rewrite complicated rational expressions with computer algebra systems.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.11 (+) Add, subtract, multiply, and divide rational expressions.

Enduring Skills:

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of other.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>How to simplify rational expressions.</p> <p>Understand that rational expressions are closed under addition, subtraction, multiplication, and division.</p>	<p>Add, subtract, multiply, and divide rational expressions.</p>	<p>Students correctly add, subtract, multiply, and divide rational expressions.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.12 Create equations and inequalities in one variable and use them to solve problems.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>How to solve linear and exponential equations in one variable.</p> <p>How to solve inequalities in one variable.</p> <p>Describe the relationships between the quantities in a problem and express these relationships using mathematical operations to create an appropriate equation or inequality to solve.</p>	<p>Solve all types of equations and inequalities in one variable.</p> <p>Create equations and inequalities in one variable to model real-world situations.</p> <p>Create equations (linear and exponential) and inequalities in one variable and use them to solve problems.</p>	<p>Students correctly solve all types of equations and inequalities in one variable.</p> <p>Students correctly create equations and inequalities to model and solve real-world problems.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.13 Create equations in two or more variables to represent relationships between quantities, graph equations on a coordinate axes with labels and scales.

Enduring Skills:

- MP.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.
- MP.6 Attend to precision.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>How to create equations in two variables to represent relationships between quantities.</p> <p>How to graph equations in two variables on a coordinate plane and label the axes and scales.</p>	<p>Create at least two equations in two or more variables to represent relationships between quantities.</p> <p>Justify which quantities in a mathematical problem or real-world situation are dependent and independent.</p> <p>Determine appropriate units for the labels and scales of a graph depicting the relationship between equations created in two or more variables.</p>	<p>Students correctly represent relationships using two equations.</p> <p>Students correctly identify dependent and independent variables and what they represent in a mathematical problem or real-world situation.</p> <p>Students correctly graph equations in two variables on a coordinate plane with appropriate labels and scales.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.14 Create a system of equations or inequalities to represent constraints within a modeling context. Interpret the solution(s) to the corresponding system as viable or nonviable options within the context.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Write and use a system of equations and/or inequalities to solve a real-world problem.</p> <p>Recognize that the equations and inequalities represent the constraints of the problem.</p>	<p>Interpret solutions as viable or nonviable options in a modeling context.</p> <p>Determine when a problem should be represented by equations, inequalities, systems of equations and/or inequalities.</p> <p>Represent constraints by equations or inequalities, and systems of equations and/or inequalities.</p>	<p>Students correctly write a system of equations and/or inequalities to solve a real-world problem.</p> <p>Students correctly identify and represent constraints of a problem.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.15 Rearrange formulas to solve a literal equation, highlighting a quantity of interest, using the same reasoning as in solving equations.

Enduring Skills:

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How to solve multi-variable or literal equations for a specific variable.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Rearrange a formula to highlight a quantity of interest. For example, solve $I=Prt$ for the variable r.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Students correctly solve literal equations for a specific given variable.</p> <p>Students recognize which variable needs to be isolated in a literal equations to solve a problem.</p>
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Algebra (KY.HS.A)

Standard: KY.HS.A.17 Solve and justify equations in one variable. Justify the solutions and give examples showing how extraneous solutions may arise.

- a. Solve rational equations written as proportions in one variable.
- b. Solve radical equations in one variable.

Enduring Skills:

- MP.2 Reason abstractly and quantitatively.
- MP.3 Construct viable arguments and critique the reasoning of others.

a. Solve rational equations written as proportions in one variable.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
How to solve rational equations in one variable.	Determine the domain of a rational function. Solve rational equations in one variable. Give examples showing how extraneous solutions may arise when solving rational equations.	Students correctly solve rational equations. Students correctly identify extraneous solutions and explain their reasoning.

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b. Solve radical equations in one variable.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How to solve radical equations in one variable.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Determine the domain of a radical function.</p> <p>Solve radical equations in one variable.</p> <p>Give examples showing how extraneous solutions may arise when solving radical equations.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Students correctly solve radical equations.</p> <p>Students correctly identify extraneous solutions and explain their reasoning.</p> <p>Students correctly identify the domain of radical functions.</p>
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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 .

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

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How to use completing the square to find solutions of quadratic equations.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Use completing the square to find solutions of quadratic equations.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Understand that completing the square can be used to find all real and imaginary roots of quadratic equations.</p>
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Algebra (KY.HS.A)

Standard: KY.HS.A.22 (+) Use matrices to solve a system of equations.

- a. Represent a system of linear equations as a single matrix equation in a vector variable.
- b. Find the inverse of a matrix if it exists.
- c. Use matrices to solve systems of linear equations (using technology for matrices of dimension 3×3 or greater).

Enduring Skills:

- MP.4 Model with mathematics.
- MP.7 Look for and make use of structure.

- a. Represent a system of linear equations as a single matrix equation in a vector variable.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Understand the relationship between a system of equations and a matrix.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Write a system of equations as a single matrix equation.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly represent a system of equations as a single matrix equation.</p>
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- b. Find the inverse of a matrix if it exists.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Understand what a matrix inverse is.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Find the inverse of a matrix.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Find the inverse of a matrix and understand some inverses do not exist.</p>
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c. Use matrices to solve systems of linear equations (using technology for matrices of dimension 3×3 or greater).

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Understand the relationship between a system of equations and a matrix.</p> <p>Understand the relationship between a system of equations and vector variable form.</p>	<p>Solve a system of equations using matrices.</p> <p>Write a system of equations as a single matrix equation and solve.</p>	<p>Students correctly solve systems of equations using a matrix representation.</p>

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Algebra (KY.HS.A)

Standard: KY.HS.A.24 Justify that the solutions of the equations $f(x) = g(x)$ are the x-coordinates of the points where the graphs of $y = f(x)$ and $y = g(x)$ intersect. Find the approximate solutions graphically, using technology or tables. ★

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of other.

MP.5 Use appropriate tools strategically.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How does a graphed solution of equations in two variables indicate the set of all its solutions?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Use technology to graph linear, polynomial, rational, absolute value, exponential, and logarithmic equations and determine their point of intersection.</p> <p>Use successive approximations that become closer and closer to the actual value.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Students correctly approximate/find the solution(s) using an appropriate method. For example, using technology to graph the functions, make table of values, or find successive approximations.</p>
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Functions (KY.HS.F)

Standard: KY.HS.F.1 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function $h(n)$ gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.

Enduring Skills:

- MP.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.
- MP.6 Attend to precision.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>What is the domain of a function?</p> <p>How would one appropriately identify domain based on the unit, quantity, and type of function?</p>	<p>Identify and describe the domain of a function, given the graph or a verbal/written description of a function.</p> <p>Identify an appropriate domain based on the unit, quantity, and type of function described.</p>	<p>Students correctly relate the domain of a function to its graph and to a verbal description of a function.</p> <p>Students correctly identify domain for a real-life function relationship and explain why that domain is appropriate.</p>

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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.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>What is the average rate of change?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Recognize slope as an average rate of change.</p> <p>Calculate the average rate of change of a function (presented symbolically or as a table) over a specified interval.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly calculate the average rate of change of a function (presented symbolically or as a table) over a specified interval.</p>
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- b. Estimate the rate of change from a graph.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>What is the average rate of change?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Estimate the rate of change from a linear or exponential graph.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly estimate the average rate of change of a function (presented symbolically or as a table) over a specified interval.</p>
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Functions (KY.HS.F)

Standard: KY.HS.F.4 Graph functions expressed symbolically and show key features of the graph, with and without using technology (computer, graphing calculator). ★

- a. Graph linear and quadratic functions and show intercepts, maxima and minima.
- b. Graph square root, cube root 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.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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>What essential information is indicated when graphing linear and quadratic functions?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Graph linear and quadratic functions by hand in simple cases or using technology for more complicated cases and show/label intercepts, maxima, and minima of the graph.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Graph simple linear and quadratic functions by hand.</p> <p>Graph simple linear and quadratic functions using technology when appropriate.</p>
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b. Graph square root, cube root and absolute value functions.

Know: <i>What content does the student need to know to demonstrate this standard?</i> What essential information is indicated when graphing square root, and cube root functions?	Do: <i>What skill must the student demonstrate?</i> Graph square root, cube root, and absolute value functions, by hand in simple cases or using technology for more complicated cases, and show/label key features of the graph.	Mastery: <i>How does the student demonstrate the learning of the standard?</i> Graph square root, cube root, and absolute value functions and know when the use of technology is appropriate. Select appropriate type of function, taking into consideration the key features.

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

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

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>What essential information is needed to graph exponential, logarithmic, and trigonometric functions?</p> <p>What are the general shapes of exponential, logarithmic, and trigonometric functions?</p>	<p>Graph exponential and logarithmic functions, showing intercepts and end behavior.</p> <p>Graph trigonometric functions, showing period, midline and amplitude.</p>	<p>Correctly graph exponential and logarithmic functions, showing intercepts and end behavior.</p> <p>Correctly graph trigonometric functions, showing period, midline and amplitude.</p>

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>What essential information is needed to graph trigonometric and step functions?</p> <p>What are the general shapes of trigonometric and step functions?</p>	<p>Graph trigonometric and step functions showing intercepts and end behavior.</p>	<p>Correctly graph trigonometric and step functions, showing intercepts and end behavior.</p>

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>What essential information is needed to graph rational functions?</p> <p>What are the general shapes of rational functions?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Graph rational showing zeros, asymptotes, and end behavior.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Graph rational functions, by hand in simple cases or using technology for more complicated cases and identify zeros when suitable factorizations are available and show end behavior.</p>
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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.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.
- MP.6 Attend to precision.

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Define zeros, extreme values, and symmetry.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Identify zeros, extreme values, and symmetry of the graph of a quadratic function.</p> <p>Identify how key features of a quadratic function relate to its characteristics in real-world context.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Given the expression of a quadratic function, interpret zeros, extreme values, and symmetry of the graph in terms of a real-world context.</p>
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b. Use the properties of exponents to interpret expressions for exponential functions and classify the exponential function as representing growth or decay.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Classify the exponential function as exponential growth or decay by examining the base.	Use the properties of exponents to interpret expressions for exponential functions in a real world context.	Write an exponential function defined by an expression in different 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.
Identify how key features of an exponential function relate to its characteristics 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.	

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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.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.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.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>What strategy can be used to write a function that describes a relationship between two quantities?</p> <p>Define explicit function and recursive process.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>From context, either write an explicit expression, define a recursive process, or describe the calculations needed to model a function between two quantities.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>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.</p>
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b. Combine standard function types using arithmetic operations.

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How to compose functions.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Perform composition of functions, such as linear and exponential.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Given a real world situation or mathematical problem, compose functions to build the appropriate combined function.</p>
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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.

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

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How can we use composition of functions to verify inverses?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Use composition of functions to prove that one function is the inverse of another.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly verify inverse functions using composition.</p>
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c. (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How are functions and their inverses related?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Describe the relationship between a function and it's inverse.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Understand a function and its inverse describe the exact same relationship, but in different ways.</p>
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d. (+) Produce an invertible function from a non-invertible function by restricting the domain.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>How can we manipulate the domain to produce invertible functions?</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Place restrictions on the domain that will produce invertible functions from non-invertible functions.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Correctly place restrictions on the domain that will produce invertible functions from non-invertible functions.</p>
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Functions (KY.HS.F)

Standard: KY.HS.F.10 Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents with the use of technology.

Enduring Skills:

MP.7 Look for and make use of structure

MP.8 Look for and express regularity in repeated reason.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Relate inverses to solving equations.</p> <p>Understand the inverse relationship between exponential and logarithmic functions.</p>	<p>Use inverses of simple logarithmic and exponential equations to solve those equations.</p>	<p>Use inverses of simple logarithmic and exponential equations to solve those equations.</p>

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Trigonometric Functions (KY.HS.F)

Standard: KY.HS.F.15 (+) Understand the relationship of radian measure of an angle to its arc length.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Understand the relationship between central angles and arc length.	Recognize that the radian measure of an angle and its arc length are equal.	Recognize that the radian measure of an angle and its arc length are equal.

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Trigonometric Functions (KY.HS.F)

Standard: KY.HS.F.16 (+) Understand and use the unit circle.

- a. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.
- b. Use special triangles to determine geometrically the values of sine, cosine, tangent for $\pi/3$, $\pi/4$ and $\pi/6$ and use the unit circle to express the values of sine, cosine and tangent for $\pi - x$, $\pi + x$ and $2\pi - x$ in terms of their values for x , where x is any real number.
- c. Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.

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. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Recognize how the trigonometric functions are related to angles graphed in the coordinate plane.	Use the unit circle to define all six trigonometric functions in terms of coordinates x and y and radius r .	Use the unit circle to define all six trigonometric functions in terms of coordinates x and y and radius r .

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b. Use special triangles to determine geometrically the values of sine, cosine, tangent for $\pi/3$, $\pi/4$ and $\pi/6$ and use the unit circle to express the values of sine, cosine and tangent for $\pi - x$, $\pi + x$ and $2\pi - x$ in terms of their values for x , where x is any real number.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Recall the properties of special right triangles.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>For $\pi/3$, $\pi/4$ and $\pi/6$ use the properties of special right triangles to find values of sine (y), cosine (x), and tangent (y/x).</p> <p>Use reference angles to find values of sine, cosine and tangent for $\pi - x$, $\pi + x$ and $2\pi - x$ in terms of their values for x.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>For $\pi/3$, $\pi/4$ and $\pi/6$ use the properties of special right triangles to find values of sine (y), cosine (x), and tangent (y/x).</p> <p>Use reference angles to find values of sine, cosine and tangent for $\pi - x$, $\pi + x$ and $2\pi - x$ in terms of their values for x.</p>
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c. Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Understand the relationship of reference angles and symmetry.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Determine the symmetry of trigonometric function.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Compare the values of trigonometric functions in quadrants I and IV to determine whether a function is odd or even.</p>
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Trigonometric Functions (KY.HS.F)

Standard: KY.HS.F.17 (+) Choose trigonometric functions to model periodic phenomena with specified period, midline and amplitude. ★

Enduring Skills:

MP.4 Model with mathematics.

MP.6 Attend to precision.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Define sinusoidal. Define period, midline, and amplitude.	Understand the real-world phenomena can be approximated by sinusoids, including sound waves, oscillation on a spring, the motion of a pendulum, tides, and phases of the moon.	Model changes in frequency and phase shift using the period, midline, and amplitude of sinusoids. Find correct solutions using technology, except in simple cases.

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Trigonometric Functions (KY.HS.F)

Standard: KY.HS.F.18 (+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.

Enduring Skills:

- MP.2 Reason abstractly and quantitatively.
- MP.3 Construct viable arguments and critique the reasoning of others.
- MP.7 Look for and make use of structure.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Recognize when a function is increasing or decreasing.</p> <p>Recall restricting domains of functions so they have an inverse.</p>	<p>Restrict the domain of a trigonometric function so that it has an inverse.</p>	<p>Choose an interval on which the function is increasing or decreasing to restrict the domain so that the function has an inverse.</p>

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Trigonometric Functions (KY.HS.F)

Standard: KY.HS.F.19 (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology and interpret them in terms of the context. ★

Enduring Skills:

- MP.2 Reason abstractly and quantitatively.
- MP.3 Construct viable arguments and critique the reasoning of others.
- MP.4 Model with mathematics.

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Understand $\sin^{-1}x$, $\cos^{-1}x$, and $\tan^{-1}x$.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Solve trigonometric equations in modeling context.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Evaluate solutions of trigonometric equations appropriately in terms of context.</p>
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Trigonometric Functions (KY.HS.F)

- Standard: KY.HS.F.20 (+)** Proving identities and formulas within the context of trigonometry.
- a. Prove the Pythagorean identity and use it to find $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ given $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ and the quadrant of the angle.
 - b. Prove the addition and subtraction formulas for sine, cosine and tangent and use them to solve problems

Enduring Skills:

- MP.3 Construct viable arguments and critique the reasoning of others.
MP.7 Look for and make use of structure.

- a. Prove the Pythagorean identity and use it to find $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ given $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ and the quadrant of the angle.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Recall the Pythagorean Identity.	Verify a Pythagorean Identity. Use Pythagorean Identities to find values of trigonometric functions, given the quadrant angle.	Verify Pythagorean Identities by transforming expressions appropriately.

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b. Prove the addition and subtraction formulas for sine, cosine and tangent and use them to solve problems

<p>Know: <i>What content does the student need to know to demonstrate this standard?</i></p> <p>Recall addition and subtraction formulas for sine, cosine, and tangent.</p>	<p>Do: <i>What skill must the student demonstrate?</i></p> <p>Understand written proofs of addition and subtraction formulas for sine, cosine, and tangent.</p> <p>Apply addition and subtraction formulas for sine, cosine, and tangent to solve problem.</p>	<p>Mastery: <i>How does the student demonstrate the learning of the standard?</i></p> <p>Understand written proofs of addition and subtraction formulas for sine, cosine, and tangent.</p> <p>Apply addition and subtraction formulas for sine, cosine, and tangent to solve problem.</p>
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Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.4 (+) When appropriate, fit a normal distribution to a numerical data set for given mean and standard deviation and then estimate population percentages using the Empirical Rule and recognize that there are data sets for which such a procedure is not appropriate.

Enduring Skills:

MP.3 Construct viable arguments and critique the reasoning of others.

MP.5 Use appropriate tools strategically.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Describe the characteristics of a normal distribution.</p> <p>Use a calculator, spreadsheet, and table to estimate areas under a normal curve.</p>	<p>Use the mean and standard deviation of a data set to fit the data set to a normal distribution.</p> <p>Use a normal distribution to estimate population percentages.</p> <p>Recognize that there are data sets for which such a procedure is not appropriate.</p>	<p>Students correctly use the given mean and standard deviation to fit a data set to a normal distribution.</p> <p>Students correctly use a normal distribution to estimate population percentages.</p> <p>Students correctly recognize situations for which a normal distribution is appropriate or inappropriate in interpreting data sets.</p>

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Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.9 Understand statistics as a process for making inferences and justifying conclusions about population parameters based on a random sample from that population.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Understand that statistics is a process for making inferences about a population parameters or characteristics.</p> <p>Understand that statistical inferences about population characteristics are based upon random samples of that population.</p>	<p>Identify the population (our group we are studying) and the parameters or characteristics (things we are wanting to measure about our group) of the statistical study.</p> <p>Identify a “random” sample of a population.</p>	<p>Students correctly identify the population group of a statistical study.</p> <p>Students correctly identify the parameters being measured in a statistical study.</p> <p>Students correctly identify “random sampling” versus non-random sampling in a statistical study and recognize the importance of a random sample.</p>

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Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.10 – Decide if a specified model is consistent with the results from a simulation.

Enduring Skills:

MP.4 Model with mathematics.

MP.6 Attend to precision.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Understand various specified data-generating processes/models (flipping coins, spinning spinners, rolling a number cube, random number generators, graphing calculator simulators, etc.)</p> <p>Recognize data that various models produce.</p> <p>Understand how data or discrepancies could provide the basis for rejecting a statistical model.</p>	<p>Determine if various data-generating models show consistency.</p>	<p>Determine if various data-generating models show consistency.</p>

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Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.11 Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

Enduring Skills:

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

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Understand the purpose of surveys, experiments, and observational studies in making statistical inferences and justifying conclusions.</p> <p>Understand the differences among surveys, experiments, and observational studies in making statistical inferences and justifying conclusions.</p> <p>Understand how randomization relates to surveys, experiments, and observational studies.</p>	<p>Explain techniques for randomly selecting study subjects from a population. Explain how this selection differs from randomly assigning existing subject to control groups or experimental groups in a statistical experiment.</p> <p>Explain the similarities and differences between the three most common types of data gathering methods: sample surveys, experiments, and observational studies.</p> <p>Explain that “randomization” is the process of selecting a random sample so that the sample represents the population as accurately as possible.</p>	<p>Students correctly explain the purpose, and differences among the three most common types of data gathering methods: sample surveys, experiments, and observational studies.</p> <p>Students understand the importance of randomizing samples so that inferences can be made about the population as a whole.</p>

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Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.12 Use data from a sample survey to estimate a population mean or proportion and explain how bias may be involved in the process.

Enduring Skills:

- MP.4 Model with mathematics.
- MP.7 Look for and make use of structure.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
Define margin of error.	Use data from a sample survey to estimate population mean or proportion.	Students correctly calculate the sample mean in order to estimate the population mean.
Understand the connection of margin of error to variation within a data set.	Interpret data generated by a simulation model for random sampling in terms of the context of simulation models.	Students correctly calculate margin of error for a population proportion and for population mean based on the size of sample.
Use simulation models to generate data for random sampling assuming certain population parameters/characteristics.	Calculate a margin of error assuming certain population parameters/characteristics, through the use of simulation models for random sampling.	

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Probability and Statistics (KY.HS.SP)

Standard: KY.HS.SP.13 Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between estimates or statistics are significant.

Enduring Skills:

- MP.3 Construct viable arguments and critique the reasoning of others.
- MP.5 Use appropriate tools strategically.

Know: <i>What content does the student need to know to demonstrate this standard?</i>	Do: <i>What skill must the student demonstrate?</i>	Mastery: <i>How does the student demonstrate the learning of the standard?</i>
<p>Understand how to simulate a randomized experiment.</p> <p>Understand how to interpret and compare data from two treatments.</p> <p>Understand how to select a reasonable level of significance.</p>	<p>Use data from a randomized experiment to compare two treatments.</p> <p>Choose appropriate methods to simulate a randomized experiment.</p> <p>Establish a reasonable level of significance.</p>	<p>Students observe two computer generated simulation models to decide how likely it is that observed differences in a randomized experiment are due to chance.</p> <p>Students correctly compare two treatments through a t-test.</p>

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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? $? - 2 = 3$
Put Together/ Take Apart²	Total Unknown Three red apples and two green apples are on the table. How many apples are on the table? $3 + 2 = ?$	Addend Unknown Five apples are on the table. Three are red and the rest are green. How many apples are green? $3 + ? = 5, 5 - 3 = ?$	Both Addends Unknown³ Grandma has five flowers. How many can she put in her red vase and how many in her blue vase? $5 = 0 + 5, 5 = 5 + 0$ $5 = 1 + 4, 5 = 4 + 1$ $5 = 2 + 3, 5 = 3 + 2$
Compare⁴	Difference Unknown ("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? $2 + ? = 5, 5 - 2 = ?$	Bigger Unknown ("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? $2 + 3 = ?, 3 + 2 = ?$	Smaller Unknown ("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.

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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	Fluently add and subtract within 20.
KY.2.NBT.5	Fluently add and subtract within 100.
KY.3.OA.7	Fluently multiply and divide within 100.
KY.3.NBT.2	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	Fluently divide multi-digit numbers using an algorithm.
KY.6.NS.3	Fluently add, subtract, multiply and divide multi-digit decimals using an algorithm for each operation.
KY.6.EE.2	Write, read and evaluate expressions in which letters stand for numbers.
KY.7.NS.1d	Apply properties of operations as strategies to add and subtract rational numbers.
KY.7.NS.2c	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	Use the structure of an expression to identify ways to rewrite it and consistently look for opportunities to rewrite expressions in equivalent forms.
KY.HS.A.19	Solve quadratic equations in one variable.
KY.HS.F.4	Graph functions expressed symbolically and show key features of the graph both with and without technology (i.e., computer, graphing calculator). ★
KY.HS.F.8	Understand the effects of transformations on the graph of a function.
KY.HS.G.21	Use coordinates to justify and prove simple geometric theorems algebraically.
KY.HS.G.11c	Use similarity criteria for triangles to solve problems in geometric figures.
KY.HS.G.12c	Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems. ★