



Side-by-Side Comparison of the Common Core College and Career Readiness Standards for Mathematics (Draft September 21, 2009) with the Kansas Curricular Standards for Mathematics (July, 2003)

Purpose

The purpose of this side-by-side comparison is to provide information to the states regarding the alignment of the Kansas Curricular Standards for Mathematics with the revised Common Core College and Career Readiness Standards for Mathematics. We hope this side-by-side proves helpful as the states formulate feedback on the quality and content of these standards. The standards will be revised based on the 30-day public review period.

Background

The Common Core College and Career Readiness Standards for Mathematics are meant to describe the essential skills and knowledge students will need to be prepared for non-remedial college mathematics courses and will be prepared for training programs for career-level jobs. In addition, the Common Core standards are intended to be focused, clear, and internationally benchmarked. [Note: These Common Core standards will be followed by K-12 standards that provide greater detail about the expectations for students at each level.]

Side-by-side comparison chart

The side-by-side comparison chart shows the correspondence between the Common Core College and Career Readiness Standards for Mathematics and the Kansas Curricular Standards for Mathematics. Following the side-by-side chart is a list of the Kansas mathematics standards for ninth and tenth grades for which Achieve found no corresponding Common Core standard. [Note: Comparisons are a matter of professional judgment, and other experts may have different impressions. In addition, the strength of the match varies from standard to standard.]

Organization of the respective documents

The Common Core College and Career Readiness Standards for Mathematics are organized into three interconnected parts: (1) A Standard for Mathematical Practice that describes characteristics, or habits of mind, of proficient mathematics students, (2) Ten Standards for Mathematical Content, and (3) Example Tasks. Each Standard for Mathematical Content contains Core Concepts, Core Skills and a narrative that provides a coherent understanding of the content. The standards are as follows:



1. Mathematical Practice
2. Number
3. Quantity
4. Expressions
5. Equations
6. Functions
7. Modeling
8. Shape
9. Coordinates
10. Probability
11. Statistics.

For purposes of this comparative analysis, both the Mathematical Practice Standard and the 10 Standards for Mathematical Content have been included in the side-by-side chart that follows.

In addition, the College and Career Readiness Standards for Mathematics document also includes Example Tasks. Over time, the collection of tasks will grow. The Example Tasks illustrate the range and variety of student performance that is expected. Example Tasks exist for Quantity, Expressions, Equations, and Modeling. For purposes of this side-by-side analysis with the ADP Benchmarks, the Explanatory Problems have not been used.

The Kansas Curricular Standards for Mathematics, published in July, 2003, are organized around the following four standards:

1. Number and Computation (N)
2. Algebra (A)
3. Geometry (G)
4. Data (D)

Numbered Benchmarks can be found under each standard, followed by two sets of explanatory indicators: Knowledge Base Indicators and Application Indicators. For this analysis all of the ninth- and tenth-grade Knowledge Base Indicators have been used with a coding schema devised so that standards could be tracked back to their original position in the



Kansas standards document. Application Indicators were used only in cases where they added to an alignment. In all cases the coding scheme has four parts as follows:

Grade level (9/10, 8, 7, or 6) – Standard letter (N, A, G, or D) – Benchmark number – Indicator type and number (K or A followed by the number of the indicator in the chart). (For example 910.N.1.K1 indicates a ninth-tenth grade standard from the Number and Computation Standard, the first Benchmark, and the first Knowledge Base Indicator.) When necessary for alignment some Kansas mathematics standards from sixth through eighth grades were also used.

In the interest of brevity the example problems and tasks included with the Indicators were used to guide the alignments but have not been included in this comparison. In those cases where a Kansas standard has multiple parts that relate to different Common Core College and Career Readiness Standards, only those parts relevant to the alignment are included in a particular alignment.

References and assessment indicators provided with the Kansas mathematics standards have been carried forward to this chart but were not considered in this analysis.

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We hope this side-by-side comparison will be helpful to you as you consider the College and Career Readiness Standards for Mathematics. Please let us know if you have any questions.

Achieve contact: Christine Tell
ctell@achieve.org or (541) 954-3783



Kansas Curricular Standards for Mathematics Addressed in the Common Core College and Career Readiness

Standards for Mathematics (Draft 9/21/09)

Note: Underlined text in some Kansas mathematics standards indicates the particular element of the benchmark that is addressed by corresponding Common Core standard

College and Career Readiness Standards for Mathematics (Sept, 2009)	Kansas Curricular Standards for Mathematics (July, 2003)	Comments
<p>In this column when there is a partial alignment the passage that has no counterpart in KA standards can be identified in red font.</p>	<p>In this column when there is a partial alignment the particular passage that connects most strongly to the CCSS counterpart is <u>underlined</u> and the passage(s) that have no counterpart in CCSS can be identified in red font. Application Indicators and the larger grained Benchmarks are used occasionally and can be identified in <i>italics</i>. Middle school standards can be identified in blue font.</p>	
Core Concepts		
<p>Mathematical Practice Proficient students expect mathematics to make sense. They take an active stance in solving mathematical problems. When faced with a non-routine problem, they have the courage to plunge in and try something, and they have the procedural and conceptual tools to carry through. They are experimenters and inventors, and can adapt known strategies to new problems. They think strategically.</p> <p>Students who engage in these practices discover ideas and gain insights that spur them to pursue mathematics beyond the classroom walls. They learn that effort counts in mathematical achievement. These are practices that expert mathematical thinkers encourage in apprentices.</p>		

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<p>Encouraging these practices in our students should be as much a goal of the mathematics curriculum as is teaching specific content topics and procedures. Taken together with the Standards for Mathematical Content, they support productive entry into college courses or career pathways.</p>		
<p>Core Practices</p>		
<p>MP1. Attend to precision. Mathematically proficient students organize their own ideas in a way that can be communicated precisely to others, and they analyze and evaluate others' mathematical thinking and strategies noting the assumptions made. They clarify definitions. They state the meaning of the symbols they choose, are careful about specifying units of measure and labeling axes, and express their answers with an appropriate degree of precision. Rather than saying, "let v be speed and let t be time," they would say "let v be the speed in meters per second and let t be the elapsed time in seconds from a given starting time." They recognize that when someone says the population of the United States in June 2008 was 304,059,724, the last few digits indicate unwarranted precision.</p>	<p>910.A.2.K1 The student knows and explains the use of variables as parameters for a specific variable situation (2.4.K1f)</p> <p>910.A.3.K7 The student uses function notation.</p> <p>910.G.1.K1 The student recognizes and compares properties of two-and three-dimensional figures using concrete objects, constructions, drawings, <u>appropriate terminology</u>, and appropriate technology (2.4.K1h).</p> <p>910.G.2.K1 The student determines and uses real number approximations (estimations) for length, width, weight, volume, temperature, time, distance, perimeter, area, surface area, and angle measurement <u>using standard and nonstandard units of measure</u> (2.4.K1a) (\$).</p> <p>910.G.2.K2 The student <u>selects and uses</u> measurement tools, <u>units of measure, and level of precision</u> appropriate for a given situation to find accurate real number representations for length, weight, volume, temperature, time, distance, area, surface area, mass, midpoint, and angle measurements (2.4.K1a) (\$).</p>	<p>KA standards do not address analysis or evaluation of the mathematical thinking of others. And although KA does not specifically require clarification of definitions in the standards, there are several references to clarified definitions in the Teacher Notes following each benchmark.</p>



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<p>MP2. Construct viable arguments. Mathematically proficient students understand and use stated assumptions, definitions and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They break things down into cases and can recognize and use counterexamples. They use logic to justify their conclusions, communicate them to others and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose.</p>	<p>910.G.1.A3 The student understands the concepts of and develops a formal or informal proof through understanding of the difference between a statement verified by proof (theorem) and a statement supported by examples (2.4.A1a)</p> <p>910.A.Benchmark 4: Models – The student develops and uses mathematical models to represent and <u>justify mathematical relationships</u> found in a variety of situations involving tenth grade knowledge and skills.</p>	<p>KA standards address proof and argument in Application Indicators and at the larger grain Benchmark level.</p>
<p>MP3. Make sense of complex problems and persevere in solving them. Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They consider analogous problems, try special cases and</p>	<p>910.A.2.A3 The student explains the mathematical reasoning that was used to solve a real-world problem using equations and inequalities and <u>analyzes the advantages and disadvantages of various strategies</u> that may have been used to solve the problem (2.4.A1c)</p>	

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<p>work on simpler forms. They evaluate their progress and change course if necessary. They try putting algebraic expressions into different forms or try changing the viewing window on their calculator to get the information they need. They look for correspondences between equations, verbal descriptions, tables, and graphs. They draw diagrams of relationships, graph data, search for regularity and trends, and construct mathematical models. They check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?”</p>	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include:</p> <p>...</p> <p>c. <u>algebraic expressions to model relationships between two successive numbers in a sequence or other numerical patterns</u> (2.1.K1c);</p> <p>d. <u>equations and inequalities to model numerical and geometric relationships</u> (1.4.K2c, 2.2.K3, 2.3.K1-2, 3.2.K7) (\$);</p> <p>e. <u>function tables to model numerical and algebraic relationships</u> (\$);</p> <p>f. <u>coordinate planes to model relationships between ordered pairs</u> and equations and inequalities and linear and quadratic functions (2.2.K1, 2.3.K1-6, 3.4.K1-8) (\$);</p> <p>...</p> <p>k. geometric models (spinners, targets, or number cubes), process models (concrete objects, pictures, diagrams, or coins), and <u>tree diagrams</u> to model probability (4.1.K1-3);</p> <p>l. <u>frequency tables, bar graphs, line graphs, circle graphs, Venn diagrams, charts, tables, single and double stem-and-leaf plots, scatter plots, box-and-whisker plots, histograms, and matrices to organize and display data</u> (4.2.K1, 4.2.K5-6) (\$);</p> <p>m. <u>Venn diagrams</u> to sort data and show relationships (1.2.K2).</p>	

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<p>MP4. Look for and make use of structure. Mathematically proficient students look closely to discern a pattern. For example, in $x^2 + 5x + 6$ they can see the 5 as $2 + 3$ and the 6 as 2×3. They recognize the significance of an existing line in a geometric figure and can add an auxiliary line to make the solution of a problem clear. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects. For example, by seeing $5 - 3(x - y)^2$ as 5 minus a positive number times a square, they see that it cannot be more than 5 for any real numbers x and y.</p>		<p>KA standards do not address the ability to identify and recognize familiar structures in expressions or equations.</p>
<p>MP5. Look for and express regularity in repeated reasoning. Mathematically proficient students pay attention to repeated calculations as they carry them out, and look both for general algorithms and for shortcuts. For example, by paying attention to the calculation of slope as they repeatedly check whether points are on the line through $(1, 2)$ with slope 3, they might abstract the equation $(y - 2)/(x - 1) = 3$. Noticing the regularity in the way terms cancel in the expansions of $(x - 1)(x + 1)$, $(x - 1)(x^2 + x + 1)$, and $(x - 1)(x^3 + x^2 + x + 1)$ leads to the general formula for the sum of a geometric series. As they work through the solution to a problem, proficient students maintain oversight of the process, while attending to the details. They continually evaluate</p>	<p>910.A.1.K1 The student identifies, states, and continues the following patterns using various formats including numeric (list or table), algebraic (symbolic notation), visual (picture, table, or graph), verbal (oral description), kinesthetic (action), and written</p> <p>a. arithmetic and geometric sequences using real numbers and/or exponents (2.4.K1a);</p> <p>b. patterns using geometric figures (2.4.K1h);</p> <p>c. algebraic patterns including consecutive number patterns or equations of functions, (2.4.K1c,e);</p> <p>d. special patterns (2.4.K1a).</p> <p>910.A.1.K2 The student generates and explains a pattern (2.4.K1f).</p> <p>910.A.1.K3 The student classify sequences as arithmetic, geometric, or neither.</p>	

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the reasonableness of their intermediate results.	910.A.1.K4 The student defines (2.4.K1a): a. a recursive or explicit formula for arithmetic sequences and finds any particular term, b. a recursive or explicit formula for geometric sequences and finds any particular term.	
<p>MP6. Make strategic decisions about the use of technological tools. Mathematically proficient students consider the available tools when solving a mathematical problem, whether pencil and paper, ruler, protractor, graphing calculator, spreadsheet, computer algebra system, statistical package, or dynamic geometry software. They are familiar enough with all of these tools to make sound decisions about when each might be helpful. They use mathematical understanding and estimation strategically, attending to levels of precision, to ensure appropriate levels of approximation and to detect possible errors. They are able to use these tools to explore and deepen their understanding of concepts.</p>	<p>910.N.3.K1 The student estimates real number quantities using various computational methods including mental math, paper and pencil, concrete objects, and/or appropriate technology (2.4.K1a) (\$)</p> <p>910.N.3.K2 The student uses various estimation strategies and explains how they were used to estimate real number quantities and algebraic expressions (2.4.K1a) (\$).</p> <p>910.N.3.K3 The student knows and explains why a decimal representation of an irrational number is an approximate value(2.4.K1a).</p> <p>910.N.4.K1 The student computes with efficiency and accuracy using various computational methods including mental math, paper and pencil, concrete objects, and appropriate technology (2.4.K1a) (\$).</p> <p>910.G.1.K1 The student recognizes and compares properties of two-and three-dimensional figures using concrete objects, constructions, drawings, appropriate terminology, and appropriate technology (2.4.K1h).</p> <p>910.G.2.K1 The student determines and uses real number approximations (estimations) for length, width, weight, volume, temperature, time, distance, perimeter, area, surface area, and angle measurement using standard and nonstandard units of measure (2.4.K1a) (\$).</p>	

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	<p>910.G.2.K2 The student <u>selects and uses measurement tools, units of measure, and level of precision appropriate for a given situation</u> to find accurate real number representations for length, weight, volume, temperature, time, distance, area, surface area, mass, midpoint, and angle measurements (2.4.K1a) (\$).</p> <p>910.G.4.K1 The student recognizes and examines two- and three-dimensional figures and their attributes including the graphs of functions on a coordinate plane using various methods including <u>mental math, paper and pencil, concrete objects, and graphing utilities or other appropriate technology</u> (2.4.K1f).</p>	
<p>Number Procedural fluency in operations with real numbers and strategic competence in approximation are grounded in an understanding of place value. The rules of arithmetic govern operations on numbers and extend to operations in algebra:</p> <ul style="list-style-type: none"> • Numbers can be added in any order with any grouping and multiplied in any order with any grouping. • Adding 0 and multiplying by 1 both leave a number unchanged. • All numbers have additive inverses, and all numbers except zero have multiplicative inverses. • Multiplication distributes over addition. <p>Subtraction and division are defined in terms of addition and multiplication, so are also governed by these rules.</p>		



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<p>The place value system bundles units into 10s, then 10s into 100s, and so on, providing an efficient way to name large numbers. Subdividing in a similar way extends this to the decimal system, which provides an address system for locating all real numbers on the number line with arbitrarily high accuracy. Place value is the basis for efficient algorithms, reducing much computation to single-digit arithmetic. Mental computation strategies also make opportunistic use of the rules of arithmetic, as when the product $5 \times 177 \times 2$ is computed at a glance to obtain 1770, rather than methodically working from left to right.</p> <p>An estimate may be more appropriate than an exact value, for example, when you want to know the number of calories in a meal. Often a result is reported using fewer digits than were calculated. A mature number sense includes having rules of thumb about how much accuracy is appropriate and understanding that accuracy to more than a few decimal places often takes substantial effort. Estimation and approximation are also useful in checking calculations.</p> <p>Rational numbers represented as fractions can be located on the number line by seeing them as numbers expressed in different units; for example, $\frac{3}{5}$ is 3 units, where each unit is $\frac{1}{5}$. However, rational numbers do not fill out the number line. There are also irrational numbers, such as π or $\sqrt{2}$. Each point on the number line then corresponds to a real number that is either rational or irrational.</p>		

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Connections to Expressions, Functions and Coordinates. The rules of arithmetic govern the manipulations of expressions and functions. Two perpendicular number lines define the coordinate plane.		
Core Concepts		
NA. The real numbers include the rational numbers and are in one-to-one correspondence with the points on the number line.	910.N.1.K2 The student <u>compares and orders</u> real numbers and/or algebraic expressions and explains the relative magnitude between them (2.4.K1a) (\$)	
	910.N.3.K4 The student knows and explains between which two consecutive integers an irrational number lies (2.4.K1a).	
NB. Quantities can be compared using division, yielding rates and ratios.	910.N.1.K2 The student compares and orders real numbers and/or algebraic expressions and explains the relative magnitude between them (2.4.K1a) (\$)	
	910.G.2.K7 The student <u>knows, explains, and uses ratios and proportions to describe rates of change</u> (2.4.K1d) (\$).	
	910.G.2.A1 The student solves real-world problems by (2.4.A1a) (\$):... e. <u>using rates of change</u>	
NC. A fraction can represent the result of dividing the numerator by the denominator; equivalent fractions have the same value.	6.N.4.K2 The student performs and explains these computational procedures: a. ▲ N <u>divides whole numbers</u> through a two-digit divisor and a four-digit dividend and <u>expresses the remainder as a whole number, fraction, or decimal</u> (2.4.K1a-b)	

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	7.N.1.K1 The student knows, explains, and uses <u>equivalent representations for rational numbers</u> and simple algebraic expressions including integers, fractions, decimals, percents, and ratios; integer bases with whole number exponents; positive rational numbers written in scientific notation with positive integer exponents; time; and money (2.4.K1a-c) (\$),	
ND. Place value and the rules of arithmetic form the foundation for efficient algorithms.	8.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... i. <u>place value models</u> (place value mats, hundred charts, base ten blocks, or unifix cubes) to compare, order, and represent numerical quantities and to model computational procedures (\$);	
Core Skills		
N1. Compare numbers and make sense of their magnitude. Include positive and negative numbers expressed as fractions, decimals, powers, and roots. Limit to square and cube roots. Include very large and very small numbers and the use of scientific notation.	910.N.1.K1 The student knows, explains, and uses equivalent representations for real numbers and algebraic expressions including integers, fractions, decimals, percents, ratios; rational number bases with integer exponents; <u>rational numbers written in scientific notation</u> ; absolute value; time; and money (2.4.K1a) (\$) 910.N.1.K2 The student compares and orders real numbers and/or algebraic expressions and explains the relative magnitude between them (2.4.K1a) (\$) 910.N.3.K4 The student knows and explains between which two consecutive integers an irrational number lies (2.4.K1a).	

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N2. Know when and how to use standard algorithms, and perform them flexibly, accurately and efficiently.	910.N.1.K3 The student knows and explains what happens to the product or quotient when a real number is multiplied or divided by (2.4.K1a): a. a rational number greater than zero and less than one, b. a rational number greater than one, c. a rational number less than zero.	The CCSS do not require matrix operations.
	910.N.2.K3 ▲ The student names, <u>uses, and describes these properties with the real number system and demonstrates their meaning</u> including the use of concrete objects (2.4.K1a) (\$): a. commutative ($a + b = b + a$ and $ab = ba$), associative [$a + (b + c) = (a + b) + c$ and $a(bc) = (ab)c$], distributive [$a(b + c) = ab + ac$], and substitution properties (if $a = 2$, then $3a = 3 \times 2 = 6$); b. identity properties for addition and multiplication and inverse properties of addition and multiplication (additive identity: $a + 0 = a$, multiplicative identity: $a \cdot 1 = a$, additive inverse: $+5 + -5 = 0$, multiplicative inverse: $8 \times 1/8 = 1$); c. symmetric property of equality (if $a = b$, then $b = a$); d. addition and multiplication properties of equality (if $a = b$, then $a + c = b + c$ and if $a = b$, then $ac = bc$) and inequalities (if $a > b$, then $a + c > b + c$ and if $a > b$, and $c > 0$ then $ac > bc$); e. zero product property (if $ab = 0$, then $a = 0$ and/or $b = 0$).	
	910.N.2.K4 The student uses and describes these properties with the real number system (2.4.K1a) (\$): a. transitive property (if $a = b$ and $b = c$, then $a = c$), b. reflexive property ($a = a$).	

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	<p>910.N.4.K1 The student <u>computes with efficiency and accuracy</u> using various computational methods including mental math, paper and pencil, concrete objects, and appropriate technology (2.4.K1a) (\$).</p> <p>910.N.4.K2 The student <u>performs and explains these computational procedures</u> (2.4.K1a):</p> <ul style="list-style-type: none"> a. N addition, subtraction, multiplication, and division using the order of operations b. multiplication or division to find (\$): <ul style="list-style-type: none"> i. a percent of a number, ii. percent of increase and decrease, iii. percent one number is of another number, iv. a number when a percent of the number is given, c. manipulation of variable quantities within an equation or inequality (2.4.K1d), d. simplification of radical expressions (without rationalizing denominators) including square roots of perfect square monomials and cube roots of perfect cubic monomials; e. simplification or evaluation of real numbers and algebraic monomial expressions raised to a whole number power and algebraic binomial expressions squared or cubed; f. simplification of products and quotients of real number and algebraic monomial expressions using the properties of exponents; g. matrix addition (\$); h. scalar-matrix multiplication (\$). 	
N3. Use mental strategies and technology to formulate, represent and solve problems.	<p>910.N.3.K1 The student estimates real number quantities using various computational methods including <u>mental math</u>, paper and pencil, concrete objects, and/or <u>appropriate technology</u> (2.4.K1a) (\$)</p>	

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<p>N4. Solve multi-step problems involving fractions and percentages. Include situations such as simple interest, tax, markups/ markdowns, gratuities and commissions, fees, percent increase or decrease, percent error, expressing rent as a percentage of take-home pay, and so on.</p>	<p>910.N.1.K1 The student <u>knows, explains, and uses</u> equivalent representations for real numbers and algebraic expressions including integers, <u>fractions, decimals, percents</u>, ratios; rational number bases with integer exponents; rational numbers written in scientific notation; absolute value; time; and money (2.4.K1a) (\$)</p> <p>910.N.4.K2 The student <u>performs and explains these computational procedures</u> (2.4.K1a): a. N addition, subtraction, multiplication, and division using the order of operations <u>b. multiplication or division to find (\$):</u> i. <u>a percent of a number,</u> ii. <u>percent of increase and decrease,</u> iii. <u>percent one number is of another number,</u> iv. <u>a number when a percent of the number is given, ...</u></p> <p>910.N.4.A1 The student generates and/or <u>solves multi-step real-world problems</u> with real numbers and algebraic expressions using computational procedures (addition, subtraction, multiplication, division, roots, and powers excluding logarithms), and mathematical concepts with (\$): ... <u>d. ▲ ■ application of percents (2.4.A1a),</u></p> <p>910.N.2.A2 The <u>student analyzes and evaluates the advantages and disadvantages of using</u> integers, whole numbers, <u>fractions</u> (including mixed numbers), decimals or irrational numbers and their rational approximations <u>in solving a given real-world problem</u> (2.4.A1a) (\$),</p>	

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<p>N5. Use estimation and approximation to solve problems. Include evaluating answers for their reasonableness, detecting errors, and giving answers to an appropriate level of precision.</p>	<p>910.N.1.A2 The student <u>determines whether or not solutions</u> to real-world problems using real numbers and algebraic expressions <u>are reasonable</u> (2.4.A1a) (\$),</p> <p>910.N.3.K1 The student estimates real number quantities using various computational methods including mental math, paper and pencil, concrete objects, and/or appropriate technology (2.4.K1a) (\$)</p> <p>910.N.3.K2 The student uses various estimation strategies and explains how they were used to estimate real number quantities and algebraic expressions (2.4.K1a) (\$).</p> <p>910.N.3.K3 The student knows and explains why a decimal representation of an irrational number is an approximate value(2.4.K1a).</p> <p>910.G.2.K1 The student determines and <u>uses real number approximations (estimations)</u> for length, width, weight, volume, temperature, time, distance, perimeter, area, surface area, and angle measurement using standard and nonstandard units of measure (2.4.K1a) (\$).</p> <p>910.G.2.K2 The <u>student selects and uses</u> measurement tools, units of measure, and <u>level of precision appropriate for a given situation</u> to find accurate real number representations for length, weight, volume, temperature, time, distance, area, surface area, mass, midpoint, and angle measurements (2.4.K1a) (\$).</p>	
<p>Quantity A quantity is an attribute of an object or phenomenon that can be specified using a number and a unit, such as 2.7 centimeters, 42 questions or</p>		



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<p>28 miles per gallon.</p> <p>The length of a football field and the speed of light are both quantities. If we choose units of miles per second, then the speed of light has a value of approximately 186,000 miles per second. But the speed of light need not be expressed in miles per second; it may be approximated by 3×10^8 meters per second or in any other unit of speed. Bare numerical values such as 186,000 do not describe quantities unless they are paired with units.</p> <p>Speed (distance divided by time), rectangular area (length multiplied by length), density (mass divided by volume), and population density (number of people divided by land area) are examples of derived quantities, obtained by multiplying or dividing quantities.</p> <p>It can make sense to add two quantities, such as when a child 51 inches tall grows 3 inches to become 54 inches tall. To be added or subtracted, quantities must be of the same type (length, area, speed, etc.); to add or subtract their values, the quantities must be expressed in the same units. Converting quantities to have the same units is like converting fractions to have a common denominator before adding or subtracting. But, even when quantities have the same units it does not always make sense to add them. For example, if a wooded park with 300 trees per acre is next to a field with 30 trees per acre, they do not have 330 trees per acre.</p>		

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<p>Doing algebra with units in a calculation reveals the units of the answer, and can help reveal a mistake if, for example, the answer comes out to be a distance when it should be a speed.</p> <p>Connections to Number, Expressions, Equations, Functions, Modeling and Statistics. Operations described under Number and Expressions govern the operations one performs on quantities, including the units involved. Quantity is an integral part of any application of mathematics, and has connections to solving problems using data, equations, functions and modeling.</p>		
Core Concepts		
<p>QA. The value of a quantity is not specified unless the units are named or understood from the context.</p>	<p>910.G.2.K1 The student determines and uses real number approximations (estimations) for length, width, weight, volume, temperature, time, distance, perimeter, area, surface area, and angle measurement <u>using standard and nonstandard units of measure</u> (2.4.K1a) (\$).</p>	<p>While KA standards address the general need for units, there is no clear reference to units being required to define a quantity.</p>
<p>QB. Quantities can be added and subtracted only when they are of the same general type (length, area, speed, etc.).</p>		<p>KA standards do not address the need for common units in computations with quantities.</p>
<p>QC. Quantities can be multiplied or divided to create new types of quantities, called derived quantities.</p>		<p>While KA standards address the use of divided quantities to express rate, they do not explicitly address the creation of derived quantities.</p>

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Core Skills		
<p>Q1. Know when and how to convert units in computations. Include the addition and subtraction of quantities of the same type expressed in different units; averaging data given in mixed units; converting units for derived quantities such as density and speed.</p>	<p>910.G.2.K3 The student <u>approximates conversions between customary and metric systems</u> given the conversion unit or formula (2.4.K1a).</p>	<p>KA standards limit unit conversion to between customary and metric systems. There is no reference to conversion between units in one system for the purposes of computation or to using conversion in dimensional analysis.</p>
<p>Q2. Use and interpret quantities and units correctly in algebraic formulas. Include specifying units when defining variables and attending to units when writing expressions and equations.</p>		<p>KA standards limit the use of quantity and units to measurement, and do not specify their use in algebraic formulas.</p>
<p>Q3. Use and interpret quantities and units correctly in graphs and data displays. Include function graphs, data tables, scatter plots and other visual displays of dimensioned data.</p>	<p>910.D.2.A3 The student uses changes in scales, intervals, and categories to help support a particular interpretation of the data (2.4.A1i).</p>	<p>While this Application Indicator addresses graphic units, including scale, KA standards do not clearly require interpretation of quantities and their units used in data in KA standards.</p>
<p>Q4. Use units as a way to understand problems and to guide the solution of multi-step problems. Include examples such as acceleration; currency conversions; people-hours; social science measures, such as deaths per 100,000; and general rate, such as points per game.</p>		<p>KA standards do not define or address using dimensional analysis as a way of solving a problem.</p>



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<p>Expressions</p> <p>Expressions use numbers, variables and operations to describe computations. The rules of arithmetic, the use of parentheses and the conventions about order of operations assure that the computation has a well-determined value.</p> <p>Reading an expression with comprehension involves analysis of its underlying structure, which may suggest a different but equivalent way of writing it that exhibits some different aspect of its meaning. For example, $p+0.05p$ can be interpreted as the addition of a 5% tax to a price p. But rewriting $p+0.05p$ as $1.05p$ shows that adding a tax is the same as multiplying by a constant factor.</p> <p>Algebraic manipulations are based on the conventions of algebraic notation and the rules of arithmetic. Heuristic mnemonic devices are not a substitute for procedural fluency. For example, factoring, expanding, collecting like terms, the rules for interpreting minus signs next to parenthetical sums, and adding fractions with a common denominator are all instances of the distributive law; the definitions for negative and rational exponents are based on the extension of the exponent laws for positive integers. The laws of exponents connect multiplication of numbers to addition of exponents and thus express the deep relationship between addition and multiplication captured by the parallel nature of the rules of arithmetic for these operations.</p>		

College and Career Readiness Standards for Mathematics (Sept, 2009)	Kansas Curricular Standards for Mathematics (July, 2003)	Comments
<p>Complex expressions are made up of simpler expressions using arithmetic operations and substitution. When simple expressions within more complex expressions are treated as single quantities, or chunks, the underlying structure of the larger expression may be more evident.</p> <p>Connections to Equations and Functions. Setting expressions equal to each other leads to equations. Expressions can define functions of the variables that appear in them, with equivalent expressions defining the same function.</p>		
Core Concepts		
<p>ExA. Expressions are constructions built up from numbers, variables, and operations, which have a numerical value when each variable is replaced with a number.</p>	<p>910.A.2.K1 The student knows and explains the use of variables as parameters for a specific variable situation (2.4.K1f)</p>	
<p>ExB. Complex expressions are made up of simpler expressions.</p>		<p>KA standards do not address the structure of complex expressions.</p>
<p>ExC. The rules of arithmetic can be applied to transform an expression without changing its value.</p>	<p>910.N.1.K1 The student knows, explains, and <u>uses equivalent representations for</u> real numbers and <u>algebraic expressions</u> including integers, fractions, decimals, percents, ratios; rational number bases with integer exponents; rational numbers written in scientific notation; absolute value; time; and money (2.4.K1a) (\$)</p>	

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	<p>910.N.4.K2 The student performs and explains these computational procedures (2.4.K1a): ...</p> <p>c. <u>manipulation of variable quantities within an equation or inequality (2.4.K1d),</u></p> <p>d. <u>simplification of radical expressions (without rationalizing denominators) including square roots of perfect square monomials and cube roots of perfect cubic monomials;</u></p> <p>e. <u>simplification or evaluation of real numbers and algebraic monomial expressions raised to a whole number power and algebraic binomial expressions squared or cubed;</u></p> <p>f. <u>simplification of products and quotients of real number and algebraic monomial expressions using the properties of exponents; ...</u></p> <p>910.N.4.K3 The student finds prime factors, greatest common factor, multiples, and the least common multiple of algebraic expressions (2.4.K1b).</p> <p>910.A.2.K2 The student manipulates variable quantities within an equation or inequality (2.4.K1e),</p>	
ExD. Rewriting expressions serves a purpose in solving problems.		KA standards do not address the purpose of rewriting expressions.
Core Skills		



College and Career Readiness Standards for Mathematics (Sept, 2009)	Kansas Curricular Standards for Mathematics (July, 2003)	Comments
<p>Ex1. See structure in expressions. For example, recognize: that the expressions $x^4 - y^4$ and $(x + y)^2 - (x - y)^2$ are differences of squares; that there are different ways to rewrite the latter expression, e.g., by expanding and collecting like terms or by factoring as a difference of squares; that p is a common factor in $p + .025p$; that an expression in the form $(x - 3)^2 + 14$ reveals its minimum value.</p>		KA standards do not require recognition of certain structures in expressions.
<p>Ex2. Manipulate simple expressions. Show procedural fluency in the following cases: factoring out common terms; factoring expressions with quadratic structure; writing in standard form sums, differences, and products of polynomials. Include completing the square and rewriting in standard form sums, differences, products, and</p>	910.N.1.K1 The student knows, explains, and uses equivalent representations for real numbers and <u>algebraic expressions</u> including integers, fractions, decimals, percents, ratios; rational number bases <u>with integer exponents</u> ; <u>rational numbers written in scientific notation</u> ; absolute value; time; and money (2.4.K1a) (\$)	The CCSS do not require matrix operations.

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quotients of simple rational expressions; rewriting expressions with negative exponents and those involving square or cube roots of a single term involving exponents.	910.N.4.K2 The student performs and explains these computational procedures (2.4.K1a): ... c. <u>manipulation of variable quantities within an equation or inequality (2.4.K1d)</u> , d. <u>simplification of radical expressions (without rationalizing denominators) including square roots of perfect square monomials and cube roots of perfect cubic monomials;</u> e. <u>simplification or evaluation of real numbers and algebraic monomial expressions raised to a whole number power and algebraic binomial expressions squared or cubed;</u> f. <u>simplification of products and quotients of real number and algebraic monomial expressions using the properties of exponents;</u> g. <u>matrix addition (\$);</u> h. <u>scalar-matrix multiplication (\$).</u> 910.N.4.K3 The student finds prime factors, greatest common factor, multiples, and the least common multiple of algebraic expressions (2.4.K1b). 910.A.2.K2 The student manipulates variable quantities within an equation or inequality (2.4.K1e),	
Ex3. Define variables and write an expression to represent a quantity in a problem. Include contextual problems.	910.A.2.A1 The student <u>represents real-world problems using variables, symbols, expressions, equations, inequalities, and simple systems of linear equations (2.4.A1c-e) (\$).</u> 910.A.2.K1 The student knows and explains the use of variables as parameters for a specific variable situation (2.4.K1f)	
Ex4. Interpret an expression that represents a quantity in terms of the context. Include interpreting parts of an expression, such as	910.A.3.A2 ▲ ■ The student interprets the meaning of the x- and y- intercepts, slope, and/or points on and off the line on a graph in the context of a real-	Recognition and interpretation of the terms and coefficients of an expression is not required



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terms, factors and coefficients.	world situation (2.4.A1e) (\$)	in KA standards.
	910.A.2.K2 The student manipulates variable quantities within an equation or inequality (2.4.K1e),	
<p>Equations</p> <p>An equation is a statement that two expressions are equal. Solutions to an equation are the values of the variables in it that make it true. If the equation is true for all values of the variables, then we call it an identity; identities are often discovered by manipulating one expression into another.</p> <p>The solutions of an equation in one variable form a set of numbers; the solutions of an equation in two variables form a set of ordered pairs, which can be graphed in the plane. Equations can be combined into systems to be solved simultaneously.</p> <p>An equation can be solved by successively transforming it into one or more simpler equations. The process is governed by deductions based on the properties of equality. For example, one can add the same constant to both sides without changing the solutions, but squaring both sides might lead to extraneous solutions. Strategic competence in solving includes looking ahead for productive manipulations and anticipating the nature and number of solutions.</p> <p>Some equations have no solutions in a given</p>		



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<p>number system, stimulating the formation of expanded number systems (integers, rational numbers, real numbers and complex numbers).</p> <p>A formula is a type of equation. The same solution techniques used to solve equations can be used to rearrange formulas. For example, the formula for the area of a trapezoid, $A = ((b_1 + b_2)/2) * h$, can be solved for h using the same deductive process.</p> <p>Inequalities can be solved in much the same way as equations. Many, but not all, of the properties of equality extend to the solution of inequalities.</p> <p>Connections to Functions, Coordinates, and Modeling. Equations in two variables may define functions. Asking when two functions have the same value leads to an equation; graphing the two functions allows for the approximate solution of the equation. Equations of lines involve coordinates, and converting verbal descriptions to equations is an essential skill in modeling.</p>		
Core Concepts		
<p>EqA. An equation is a statement that two expressions are equal.</p>	<p>6.A.2.A1 The student represents real-world problems using variables and symbols to (2.4.A1a,e) (\$):</p> <p>a. write algebraic or numerical expressions or one-step equations (addition, subtraction, multiplication, division) with whole number solutions,</p> <p>b. ▲ ■ write and/or solve one-step equations (addition, subtraction, multiplication, and division),</p>	

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EqB. The solutions of an equation are the values of the variables that make the resulting numerical statement true.		While there are references to a "solution" of a problem in KA standards beginning in first grade, there is no definition relating a solution to a truth.
EqC. The steps in solving an equation are guided by understanding and justified by logical reasoning.	910.A.2.A3 The student explains the <u>mathematical reasoning that was used to solve a real-world problem using equations</u> and inequalities and analyzes the advantages and disadvantages of various strategies that may have been used to solve the problem (2.4.A1c). 910.G.1.A3 The student understands the concepts of and develops a formal or informal proof through understanding of the difference between a statement verified by proof (theorem) and a statement supported by examples (2.4.A1a).	
EqD. Equations not solvable in one number system may have solutions in a larger system.	910.N.2.K1 The student explains and illustrates <u>the relationship between the subsets of the real number system</u> [natural (counting) numbers, whole numbers, integers, rational numbers, irrational numbers] using mathematical models (2.4.K1a) 910.N.2.K2 The student identifies all the subsets of the real number system [natural (counting) numbers, whole numbers, integers, rational numbers, irrational numbers] to which a given number belongs (2.4.K1m).	
Core Skills		
Eq1. Understand a problem and formulate an equation to solve it. Extend to inequalities and systems.	910.A.2.A1 The student <u>represents real-world problems using variables, symbols, expressions, equations, inequalities, and simple systems of linear equations</u> (2.4.A1c-e) (\$).	

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<p>Eq2. Solve equations in one variable using manipulations guided by the rules of arithmetic and the properties of equality. Solve linear equations with procedural fluency. For quadratic equations, include solution by inspection, by factoring, or by using the quadratic formula. Understand that the quadratic formula comes from completing the square. Include simple absolute value equations solvable by direct inspection and by understanding the interpretation of absolute value as distance.</p>	<p>910.A.2.K3 The student solves (2.4.K1d) (\$):</p> <ul style="list-style-type: none"> a. <u>N linear equations</u> and inequalities both <u>analytically</u> and graphically; b. <u>quadratic equations with integer solutions</u> (may be solved by trial and error, graphing, quadratic formula, or factoring); c. <u>▲ N systems of linear equations</u> with two unknowns using integer coefficients and constants; d. radical equations with no more than one inverse operation around the radical expression; e. <u>equations where the solution to a rational equation can be simplified as a linear equation with a nonzero denominator</u>, f. <u>equations and inequalities with absolute value quantities</u> containing one variable <u>with a special emphasis on</u> using a number line and <u>the concept of absolute value</u>. g. <u>exponential equations</u> with the same base without the aid of a calculator or computer. 	
<p>Eq3. Rearrange formulas to isolate a quantity of interest. Exclude cases that require extraction of roots or inverse functions.</p>	<p>910.A.2.K2 The student manipulates variable quantities within an equation or inequality (2.4.K1e),</p>	<p>It is unclear whether “manipulation of variable quantities” includes isolation of a particular variable.</p>

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<p>Eq4. Solve systems of equations. Focus on pairs of simultaneous linear equations in two variables. Include algebraic techniques, graphical techniques and solving by inspection.</p>	<p>910.A.2.K3 The student <u>solves</u> (2.4.K1d) (\$):</p> <ul style="list-style-type: none"> a. N linear equations and inequalities both analytically and graphically; b. quadratic equations with integer solutions (may be solved by trial and error, graphing, quadratic formula, or factoring); c. ▲ N <u>systems of linear equations with two unknowns using integer coefficients and constants</u>; d. radical equations with no more than one inverse operation around the radical expression; e. equations where the solution to a rational equation can be simplified as a linear equation with a nonzero denominator, f. equations and inequalities with absolute value quantities containing one variable with a special emphasis on using a number line and the concept of absolute value. g. exponential equations with the same base without the aid of a calculator or computer. <p>910.G.4.K8 The student explains the relationship between the solution(s) to systems of equations and systems of inequalities in two unknowns and their corresponding graphs (2.4.K1f),</p>	
<p>Eq5. Solve linear inequalities in one variable and graph the solution set on a number line. Emphasize solving the associated equality and determining on which side of the solution of the associated equation the solutions to the inequality lie.</p>	<p>6.G.4.A1 The student represents, generates, and/or <u>solves real-world problems using a number line</u> with integer values (2.4.A1a)</p> <p>910.A.2.K3 The student <u>solves</u> (2.4.K1d) (\$):</p> <ul style="list-style-type: none"> a. N <u>linear equations and inequalities both analytically and graphically</u>; ... 	<p>KA high school standards address solving linear inequalities graphically while the Grade 6 KA standard adds the notion of using a number line to graph the solution.</p>

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<p>Eq6. Graph the solution set of a linear inequality in two variables on the coordinate plane. Emphasize graphing the associated equation, using a dashed or solid line as appropriate and shading to indicate the half-plane on which the solutions to the inequality lie.</p>	<p>910.A.2.K3 The student <u>solves</u> (2.4.K1d) (\$): a. <u>N linear equations and inequalities both analytically and graphically;</u></p> <p>910.G.4.K8 The student explains the relationship between the solution(s) to systems of equations and systems of <u>inequalities in two unknowns and their corresponding graphs</u> (2.4.K1f),</p>	
<p>Functions Functions model situations where one quantity determines another. For example, the return on \$10,000 invested at an annualized percentage rate of 4.25% is a function of the length of time the money is invested. Because nature and society are full of dependencies between quantities, functions are important tools in the construction of mathematical models.</p> <p>In school mathematics, functions usually have numerical inputs and outputs and are often defined by an algebraic expression. For example, the time in hours it takes for a plane to fly 1000 miles is a function of the plane's average ground speed in miles per hour, v; the rule $T(v) = 1000/v$ expresses this relationship algebraically and defines a function whose name is T.</p> <p>The set of possible inputs to a function is called its domain. We often infer the domain to be all inputs for which the expression defining a function has a value, or for which the function makes sense in a given context. The graph of a function is a useful</p>		



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<p>way of visualizing the relationship the function models, and manipulating the expression for a function can throw light on the function's properties.</p> <p>Two important families of functions characterized by laws of growth are linear functions, which grow at a constant rate, and exponential functions, which grow at a constant percent rate. Linear functions with an initial value of zero describe proportional relationships.</p> <p>Connections to Expressions, Equations, Modeling and Coordinates. Determining an output value for a particular input involves evaluating an expression; finding inputs that yield a given output involves solving an equation. The graph of a function f is the same as the solution set of the equation $y = f(x)$. Questions about when two functions have the same value lead to equations, whose solutions can be visualized from the intersection of the graphs. Since functions describe relationships between quantities, they are frequently used in modeling. Sometimes functions are defined by a recursive process, which can be modeled effectively using a spreadsheet or other technology.</p>		
Core Concepts		
<p>FA. A function is a rule, often defined by an expression, that assigns a unique output for every input.</p>	<p>910.A.3.K3 The student determines whether a graph, list of ordered pairs, table of values, or rule represents a function (2.4.K1e-f).</p>	<p>Different terminology is used in KA standards to describe the inputs and outputs (for</p>

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	910.A.3.K5 The student identifies domain and range of: a. relationships given the graph or table (2.4.K1e-f), b. linear, constant, and quadratic functions given the equation(s) (2.4.K1d). 910.A.3.K9 The student describes the difference between independent and dependent variables and identifies independent and dependent variables (\$). 910.G.4.K2 The student determines if a given point lies on the graph of a given line or parabola without graphing and justifies the answer (2.4.K1f).	example domain and range, dependent and independent variables). However, the requirement that students understand the concept of inputs and outputs in a function is the same.
FB. The graph of a function f is a set of ordered pairs $(x, f(x))$ in the coordinate plane.	910.A.3.K8 The student evaluates function(s) given a specific domain (\$). 910.G.4.K2 The student determines if a given point lies on the graph of a given line or parabola without graphing and justifies the answer (2.4.K1f).	
FC. Functions model situations where one quantity determines another.	910.A.3.K8 The student evaluates function(s) given a specific domain (\$). 910.A.3.K9 The student describes the difference between independent and dependent variables and identifies independent and dependent variables (\$). 910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. <u>Mathematical models include:</u> ... e. <u>function tables</u> to model numerical and algebraic relationships (2.1.K1c, 2.2.K2, 2.3.K1, 2.3.K3, 2.3.K5) (\$);...	

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	910.G.4.K2 The student determines if a given point lies on the graph of a given line or parabola without graphing and justifies the answer (2.4.K1f).	
FD. Common functions occur in families where each member describes a similar type of dependence.	910.A.3.A3 The student analyzes (2.4.A1c-e): a. the effects of parameter changes (scale changes or restricted domains) on the appearance of a function's graph,	Function families are not specifically addressed in KA standards. However, there is this reference to the effect of changing parameters on a function's graph, which would generate a function's family.
Core Skills		
F1. Recognize proportional relationships and solve problems involving rates and ratios. Include being able to express proportional relationships as functions.	910.G.2.K7 The student knows, explains, and uses ratios and proportions to describe rates of change (2.4.K1d) (\$). 910.G.2.A1 The student solves real-world problems by (2.4.A1a) (\$):... e. using rates of change	
F2. Describe the qualitative behavior of common types of functions using graphs and tables. Identify: intercepts; intervals where the function is increasing, decreasing, positive or negative; relative maximums and minimums; symmetries; end	910.A.Benchmark 4: Computation – The student <u>models, performs, and explains</u> computation with real numbers and <u>polynomials</u> in a variety of situations. 910.A.2.K1 The student knows and explains the use of variables as parameters for a specific variable situation (2.4.K1f)	KA standards address the behavior of linear and simple quadratic functions but do not cover many of the function types listed in the CCSS. Polynomials are addressed

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<p>behavior; and periodicity. Use technology to explore the effects of parameter changes on the graphs of linear, power, quadratic, polynomial, simple rational, exponential, logarithmic, sine and cosine, absolute value and step functions.</p>	<p>910.A.2.K3 The student solves (2.4.K1d) (\$):</p> <p>a. <u>N linear equations and inequalities both analytically and graphically</u>;</p> <p>b. <u>quadratic equations</u> with integer solutions (may be solved by trial and error, graphing, quadratic formula, or factoring); ...</p> <p>e. <u>equations where the solution to a rational equation can be simplified as a linear equation with a nonzero denominator</u>,</p> <p>f. <u>equations and inequalities with absolute value</u> quantities containing one variable with a special emphasis on using a number line and the concept of absolute value.</p> <p>g. <u>exponential equations</u> with the same base without the aid of a calculator or computer,</p> <p>910.A.3.K1 The student evaluates and <u>analyzes functions using</u> various methods including mental math, paper and pencil, concrete objects, and <u>graphing utilities</u> or other appropriate technology (2.4.K1a,d-f).</p> <p>910.A.3.K2 The student matches equations and graphs of constant and <u>linear functions and quadratic functions</u> limited to $y = ax^2 + c$ (2.4.K1d,f).</p> <p>910.A.3.K3 The student <u>determines whether a graph, list of ordered pairs, table of values, or rule represents a function</u> (2.4.K1e-f).</p> <p>910.A.3.K4 The student determines x- and y-intercepts and maximum and minimum values of the portion of the graph that is shown on a coordinate plane (2.4.K1f).</p>	<p>only in terms if computations involving polynomial expressions; quadratics are most often limited to those of the form $y = ax^2 + c$; rational, absolute value, and exponential functions are treated with respect to equation solving only; and rational, trigonometric, and step or other piecewise functions are left unmentioned. In addition, there are few references to graphic characteristics particular to the types of functions.</p>

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	<p>910.A.3.K5 The student <u>identifies domain and range of:</u></p> <p>a. <u>relationships given the graph or table</u> (2.4.K1e-f),</p> <p>b. linear, constant, and quadratic functions given the equation(s) (2.4.K1d).</p> <p>910.A.3.K6 ▲ The student recognizes how changes in the constant and/or slope within a linear function changes the appearance of a graph (2.4.K1f) (\$).</p> <p>910.G.4.K7 The student recognizes the equation $y = ax^2 + c$ as a parabola; represents and identifies characteristics of the parabola including opens upward or opens downward, steepness (wide/narrow), the vertex, maximum and minimum values, and line of symmetry; and sketches the graph of the parabola (2.4.K1f).</p>	
<p>F3. Analyze functions using symbolic manipulation. Include slope-intercept and point-slope form of linear functions; factored form to find horizontal intercepts; vertex form of quadratic functions to identify symmetry and find maximums and minimums; factored form to find zeros. Use manipulations as described under Expressions.</p>	<p>910.N.4.K2 The student performs and explains these computational procedures (2.4.K1a):...</p> <p>c. manipulation of variable quantities within an equation or inequality (2.4.K1d), ...</p> <p>910.A.2.K3 The student solves (2.4.K1d) (\$):...</p> <p>b. quadratic equations with integer solutions (<u>may be solved by</u> trial and error, graphing, quadratic formula, or <u>factoring</u>);...</p> <p>910.A.3.K1 The student evaluates and <u>analyzes functions using</u> various methods including mental math, paper and pencil, concrete objects, and graphing utilities or other appropriate technology (2.4.K1a,d-f).</p> <p>910.G.4.K2 The student determines if a given point lies on the graph of a given line or parabola without graphing and justifies the answer (2.4.K1f).</p>	<p>KA standards most often limit quadratic equations to the form $y = ax^2 + c$, as is the case in 910.G.4.K7 where students must recognize the characteristics of a parabola from the equation. However there is no specific requirement in KA that students use symbolic manipulation to identify those characteristics other than through solution types or general function analysis.</p>

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	<p>910.G.4.K6 ▲ The student recognizes the equation of a line and transforms the equation into slope-intercept form in order to identify the slope and y-intercept and uses this information to graph the line (2.4.K1f).</p> <p>910.G.4.K7 The student recognizes the equation $y = ax^2 + c$ as a parabola; represents and identifies characteristics of the parabola including opens upward or opens downward, steepness (wide/narrow), the vertex, maximum and minimum values, and line of symmetry; and sketches the graph of the parabola (2.4.K1f).</p>	
<p>F4. Use the families of linear and exponential functions to solve problems. For linear functions $f(x) = mx + b$, understand b as the intercept or initial value and m as the slope or rate of change. For exponential functions $f(x) = a \cdot b^x$, understand a as the intercept or initial value and b as the growth factor.</p>	<p>910.A.2.K1 The student knows and explains the use of variables as parameters for a specific variable situation (2.4.K1f)</p> <p>910.A.2.K3 The student solves (2.4.K1d) (\$):</p> <ul style="list-style-type: none"> a. <u>N linear equations</u> and inequalities both analytically and graphically; b. quadratic equations with integer solutions (may be solved by trial and error, graphing, quadratic formula, or factoring); c. ▲ <u>N systems of linear equations</u> with two unknowns using integer coefficients and constants; d. radical equations with no more than one inverse operation around the radical expression; e. equations where the solution to a rational equation can be simplified as a linear equation with a nonzero denominator, f. equations and inequalities with absolute value quantities containing one variable with a special emphasis on using a number line and the concept of absolute value. 	<p>While KA standards require use of linear and exponential equations in problem solving, there is no specific reference to their function families.</p>

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	g. <u>exponential equations</u> with the same base without the aid of a calculator or computer.	
<p>F5. Find and interpret rates of change. Compute the rate of change of linear functions and make qualitative observations about how the rate of change varies for nonlinear functions.</p>	910.G.2.K7 The student knows, explains, and uses ratios and proportions to describe rates of change (2.4.K1d) (\$).	Rates of change associated with nonlinear functions are not addressed in KA standards.
<p>Modeling Modeling uses mathematics to help us make sense of the real world—to understand quantitative relationships, make predictions, and propose solutions.</p> <p>A model can be very simple, such as a geometric shape to describe a physical object like a coin. Even so simple a model involves making choices. It is up to us whether to model the solid nature of the coin with a three-dimensional cylinder, or whether a two-dimensional disk works well enough for our purposes. For some purposes, we might even choose to adjust the right circular cylinder to model more closely the way the coin deviates from the cylinder.</p> <p>In any given situation, the model we devise depends on a number of factors: How precise an answer do we want or need? What aspects of the situation do we most need to understand, control, or optimize? What resources of time and tools do we have? The range of models we can create and analyze is constrained as well by the limitations of our mathematical and technical skills. For example,</p>		



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<p>modeling a physical object, a delivery route, a production schedule, or a comparison of loan amortizations each requires different sets of tools. Networks, spreadsheets and algebra are powerful tools for understanding and solving problems drawn from different types of real-world situations. One of the insights provided by mathematical modeling is that essentially the same mathematical structure might model seemingly different situations.</p> <p>The basic modeling cycle is one of (1) identifying the key features of a situation, (2) creating geometric, algebraic or statistical objects that describe key features of the situation, (3) analyzing and performing operations on these objects to draw conclusions and (4) interpreting the results of the mathematics in terms of the original situation. Choices and assumptions are present throughout this cycle.</p> <p>Connections to Quantity, Equations, Functions, Shape, Coordinates and Statistics. Modeling makes use of shape, data, graphs, equations and functions to represent real-world quantities and situations.</p>		
Core Concepts		

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<p>MA. Mathematical models involve choices and assumptions that abstract key features from situations to help us solve problems.</p>	<p>910.A.4.K1 The student <u>knows, explains, and uses mathematical models</u> to represent and explain mathematical concepts, procedures, and relationships...</p>	<p>This KA standard includes a list of different types of models and their representations that demonstrate several situations and choices that may be available to use to solve problems. There is, however, no reference to the choices and assumptions that accompany the variety of available models.</p>
<p>MB. Even very simple models can be useful.</p>		<p>KA standards do not specifically address the usefulness of simple models.</p>
Core Skills		
<p>M1. Model numerical situations. Include readily applying the four basic operations in combination to solve multi-step quantitative problems with dimensioned quantities; making estimates to introduce numbers into a situation and</p>	<p>910.N.2.K1 The student explains and illustrates the relationship between the subsets of the real number system [natural (counting) numbers, whole numbers, integers, rational numbers, irrational numbers] <u>using mathematical models</u> (2.4.K1a)</p>	

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<p>get problems started; recognizing proportional or near-proportional relationships and analyzing them using characteristic rates and ratios.</p>	<p>910.N.2.K3 ▲ The student names, uses, and describes these properties with the real number system and demonstrates their meaning <u>including the use of concrete objects</u> (2.4.K1a) (\$):</p> <p>a. commutative ($a + b = b + a$ and $ab = ba$), associative [$a + (b + c) = (a + b) + c$ and $a(bc) = (ab)c$], distributive [$a(b + c) = ab + ac$], and substitution properties (if $a = 2$, then $3a = 3 \times 2 = 6$);</p> <p>b. identity properties for addition and multiplication and inverse properties of addition and multiplication (additive identity: $a + 0 = a$, multiplicative identity: $a \cdot 1 = a$, additive inverse: $+5 + -5 = 0$, multiplicative inverse: $8 \times 1/8 = 1$);</p> <p>c. symmetric property of equality (if $a = b$, then $b = a$);</p> <p>d. addition and multiplication properties of equality (if $a = b$, then $a + c = b + c$ and if $a = b$, then $ac = bc$) and inequalities (if $a > b$, then $a + c > b + c$ and if $a > b$, and $c > 0$ then $ac > bc$);</p> <p>e. zero product property (if $ab = 0$, then $a = 0$ and/or $b = 0$).</p> <p>910.N.3.K1 The student estimates real number quantities using various computational methods including mental math, paper and pencil, concrete objects, and/or appropriate technology (2.4.K1a) (\$)</p> <p>910.N.3.K2 The student uses various estimation strategies and explains how they were used to estimate real number quantities and algebraic expressions (2.4.K1a) (\$).</p> <p>910.N.4.K1 The student computes with efficiency and accuracy <u>using various computational methods including</u> mental math, paper and pencil, <u>concrete objects</u>, and appropriate technology (2.4.K1a) (\$).</p>	

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	910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: a. <u>process models</u> (concrete objects, pictures, diagrams, number lines, hundred charts, measurement tools, multiplication arrays, division sets, or coordinate grids) <u>to model computational procedures</u> , algebraic relationships, and mathematical relationships and to solve equations b. <u>factor trees to model least common multiple, greatest common factor, and prime factorization</u> (1.4.K3); ... e. <u>function tables to model numerical</u> and algebraic relationships (\$);	
M2. Model physical objects with geometric shapes. Include common objects that can reasonably be idealized as two- and three-dimensional geometric shapes. Identify the ways in which the actual shape varies from the idealized geometric model.	910.A.1.K1 The student identifies, states, and continues the following patterns using various formats including numeric (list or table), algebraic (symbolic notation), <u>visual (picture, table, or graph)</u> , verbal (oral description), kinesthetic (action), and written ... b. <u>patterns using geometric figures</u> (2.4.K1h); ...	

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	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ...</p> <p>f. <u>coordinate planes to model relationships between ordered pairs and equations and inequalities and linear and quadratic functions (2.2.K1, 2.3.K1-6, 3.4.K1-8) (\$);</u></p> <p>g. <u>constructions to model geometric theorems and properties (3.1.K2, 3.1.K6);</u></p> <p>h. <u>two- and three-dimensional geometric models (geoboards, dot paper, coordinate plane, nets, or solids) and real-world objects to model perimeter, area, volume, and surface area, properties of two- and three-dimensional figures, and isometric views of three-dimensional figures;</u></p> <p>i. <u>scale drawings to model large and small real-world objects; ...</u></p> <p>k. <u>geometric models (spinners, targets, or number cubes), process models (concrete objects, pictures, diagrams, or coins), and tree diagrams to model probability (4.1.K1-3); ...</u></p>	

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<p>M3. Model situations with equations and inequalities. Include situations well described by a linear inequality in two variables or a system of linear inequalities defining a region in the plane.</p>	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... c. <u>algebraic expressions to model relationships between two successive numbers in a sequence or other numerical patterns (2.1.K1c);</u> d. <u>equations and inequalities to model numerical and geometric relationships (1.4.K2c, 2.2.K3, 2.3.K1-2, 3.2.K7) (\$);</u> e. <u>function tables to model numerical and algebraic relationships (\$);</u> f. <u>coordinate planes to model relationships between ordered pairs and equations and inequalities and linear and quadratic functions (2.2.K1, 2.3.K1-6, 3.4.K1-8) (\$); ...</u></p>	
<p>M4. Model situations with common functions. Include situations well described by linear, quadratic or exponential functions; and situations that can be well described by inverse variation $f(x) = k/x$. Include identifying a family of functions that models features of a problem, and identifying a particular function of that family and adjusting it to fit by changing parameters. Understand the recursive nature of situations modeled by linear and exponential functions.</p>	<p>910.A.1.K1 The student identifies, states, and continues the following patterns using various formats including numeric (list or table), algebraic (symbolic notation), visual (picture, table, or graph), verbal (oral description), kinesthetic (action), and written a. <u>arithmetic and geometric sequences using real numbers and/or exponents (2.4.K1a); ...</u> 910.A.1.K3 The student classify sequences as arithmetic, geometric, or neither. 910.A.1.K4 The student defines (2.4.K1a): a. a recursive or explicit formula for arithmetic sequences and finds any particular term, b. a recursive or explicit formula for geometric sequences and finds any particular term.</p>	

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	<p>910.A.3.K6 ▲ The student recognizes how changes in the constant and/or slope within a linear function changes the appearance of a graph (2.4.K1f) (\$).</p> <p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... c. <u>algebraic expressions to model relationships between two successive numbers in a sequence or other numerical patterns</u> (2.1.K1c); d. <u>equations and inequalities to model numerical and geometric relationships</u> (1.4.K2c, 2.2.K3, 2.3.K1-2, 3.2.K7) (\$); e. <u>function tables to model numerical and algebraic relationships</u> (\$) (2.1.K1c, 2.2.K2, 2.3.K1, 2.3.K3, 2.3.K5) ; ...</p>	
<p>M5. Model situations using probability and statistics. Include using simulations to model probabilistic situations; describing the shape of a distribution of values and summarizing a distribution with measures of center and variability; modeling a bivariate relationship using a trend line or a regression line.</p>	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... j. Pascal's Triangle to model binomial expansion and probability; k. geometric models (spinners, targets, or number cubes), process models (concrete objects, pictures, diagrams, or coins), and tree diagrams to <u>model probability</u> (4.1.K1-3); <u>l. frequency tables, bar graphs, line graphs, circle graphs, Venn diagrams, charts, tables, single and double stem-and-leaf plots, scatter plots, box-and-whisker plots, histograms, and matrices to organize and display data</u> (4.2.K1, 4.2.K5-6) (\$); m. Venn diagrams to sort data and show</p>	

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	relationships (1.2.K2). 910.D.2.K5 ▲ a The student approximates a line of best fit given a scatter plot and makes predictions using the graph or the equation of that line (2.4.K1k).	
<p>M6. Interpret the results of applying a model and compare models for a particular situation. Include realizing that models seldom fit exactly and so there can be error; identifying simple sources of error and being careful not to over-interpret models. Include recognizing that there can be many models that relate to a situation, that they can capture different aspects of the situation, that they can be simpler or more complex, and that they can have a better or worse fit to the situation and the questions being asked.</p>	910.A.4.K1 The student knows, <u>explains, and uses mathematical models</u> to represent and explain mathematical concepts, procedures, and relationships.	While the wide variety of models that may be used for the same problem is addressed in this KA standard, there is no specific requirement for students to compare the models.
<p>Shape From only a few axioms, the deductive method of Euclid generates a rich body of theorems about geometric objects, their attributes and relationships. Once understood, those attributes and relationships can be applied in diverse practical situations—interpreting a schematic drawing, estimating the amount of wood needed to frame a sloping roof, rendering computer graphics, or designing a sewing pattern for the most efficient use of material.</p> <p>Understanding the attributes of geometric objects</p>		



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<p>often relies on measurement: a circle is a set of points in a plane at a fixed distance from a point; a cube is bounded by six squares of equal area; when two parallel lines are crossed by a transversal, pairs of corresponding angles are congruent.</p> <p>The concepts of congruence, similarity and symmetry can be united under the concept of geometric transformation. Reflections and rotations each explain a particular type of symmetry, and the symmetries of an object offer insight into its attributes—as when the reflective symmetry of an isosceles triangle assures that its base angles are congruent. Applying a scale transformation to a geometric figure yields a similar figure. The transformation preserves angle measure, and lengths are related by a constant of proportionality. If the constant of proportionality is one, distances are also preserved (so the transformation is a rigid transformation) and the figures are congruent.</p> <p>The definitions of sine, cosine and tangent for acute angles are founded on right triangle similarity, and, with the Pythagorean theorem, are fundamental in many practical and theoretical situations.</p> <p>Connections to Coordinates, Functions and Modeling. The Pythagorean theorem is a key link between geometry, measurement and distance in the coordinate plane. Parameter changes in families of functions can be interpreted as transformations applied to their graphs and those</p>		

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functions, as well as geometric objects in their own right, can be used to model contextual situations.		
Core Concepts		
SpA. Shapes and their parts, attributes, and their measurements can be analyzed deductively.	910.G.1.A2 The student <u>uses deductive reasoning</u> to justify the relationships between the sides of 30°-60°-90° and 45°-45°-90° triangles using the ratios of sides of similar triangles (2.4.A1a). 910.G.1.A3 The student understands the concepts of and develops a formal or informal proof through understanding of the difference between <u>a statement verified by proof</u> (theorem) and a statement supported by examples (2.4.A1a).	Proof is handled only generally in the KA standards with the exception of one specific reference to proof of the properties of special right triangles.
SpB. Congruence, similarity, and symmetry can be analyzed using transformations.	910.G.1.K3 The student recognizes and <u>describes the symmetries</u> (point, line, plane) that exist in three-dimensional figures (2.4.K1h). 910.G.1.K4 The student recognizes that <u>similar figures</u> have congruent angles, and their corresponding sides are proportional (2.4.K1h). 910.G.1.K6 The student recognizes and describes (2.4.K1g-h): a. <u>congruence of triangles</u> using: Side-Side-Side (SSS), Angle-Side-Angle (ASA), Side-Angle-Side (SAS), and Angle-Angle-Side (AAS); b. the ratios of the sides in special right triangles: 30°-60°-90° and 45°-45°-90°. 910.G.2.K6 The student recognizes and applies properties of corresponding parts of similar and congruent figures to find measurements of missing sides (2.4.K1a).	While each of the concepts is represented separately, the understanding of the ability to use transformations in the analysis of congruence, similarity, and symmetry is not clearly required in KA standards. The CCSS does not require tessellations.

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	910.G.3.K1 The student <u>describes and performs single and multiple transformations</u> [reflection, rotation, translation, reduction (contraction/shrinking), enlargement (magnification/growing)] on two- and three-dimensional figures (2.4.K1a). 910.G.3.K4 The student determines where and how an object or a shape can be tessellated using single or multiple transformations and creates a tessellation (2.4.K1a).	
SpC. Mathematical shapes model the physical world, resulting in practical applications of geometry.	910.A.4.A1 The student recognizes that various mathematical models can be used to represent the same problem situation. Mathematical models include: ... f. <u>two- and three-dimensional geometric models</u> (geoboards, dot paper, coordinate plane, nets, or solids) and real-world objects to model perimeter, area, volume, and surface area, properties of two- and three-dimensional figures and isometric views of three-dimensional figures g. <u>scale drawings to model large and small real-world objects</u> h. <u>geometric models</u> (spinners, targets, or number cubes), process models (coins, pictures, or diagrams), and tree diagrams to model probability	
SpD. Right triangles and the Pythagorean theorem are central to geometry and its applications, including trigonometry.	910.G.1.K5 The student uses the Pythagorean Theorem to (2.4.K1h): a. determine if a triangle is a right triangle, b. find a missing side of a right triangle. 910.G.4.K5 The student uses the Pythagorean Theorem to find distance (may use the distance formula) (2.4.K1f).	
Core Skills		

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<p>Sp1. Use multiple geometric properties to solve problems involving geometric figures. Properties include: measures of interior angles of a triangle sum to 180°; vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; measures of supplementary angles sum to 180°; two lines parallel to a third are parallel to each other; points on a perpendicular bisector of a segment are exactly those equidistant from the segment's endpoints; and a line tangent to a circle is perpendicular to the radius meeting it.</p>	<p>910.G.1.K2 The student discusses properties of regular polygons related to (2.4.K1g-h): a. angle measures, b. diagonals.</p> <p>910.G.1.K7 The student recognizes, describes, and compares the relationships of the angles formed when parallel lines are cut by a transversal (2.4.K1h).</p> <p>910.G.1.K8 The student recognizes and identifies parts of a circle: arcs, chords, sectors of circles, secant and tangent lines, central and inscribed angles (2.4.K1h).</p> <p>910.G.1.A1 The student solves real-world problems by (2.4.A1a): a. using the properties of corresponding parts of similar and congruent figures, e.g., scale drawings, map reading, or proportions; b. ▲ ■ applying the Pythagorean Theorem, e.g., when checking for square corners on concrete forms for a foundation, determine if a right angle is formed by using the Pythagorean Theorem; c. using properties of parallel lines, e.g., street intersections.</p>	
<p>Sp2. Prove theorems, test conjectures and identify logical errors. Include theorems establishing the properties in Core Skill 1 and other theorems about angles, parallel and perpendicular lines, similarity and congruence of triangles.</p>	<p>910.G.1.A2 The student <u>uses deductive reasoning</u> to justify the relationships between the sides of 30°-60°-90° and 45°-45°-90° triangles using the ratios of sides of similar triangles (2.4.A1a).</p> <p>910.G.1.A3 The student understands the concepts of and develops a formal or informal proof through understanding of the difference between <u>a statement verified by proof</u> (theorem) and a statement supported by examples (2.4.A1a).</p>	<p>Proof is handled only generally in the KA standards with the exception of one specific reference to proof of the properties of special right triangles. In addition there are a few KA standards that address the specific geometric properties that may be proven.</p>

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	910.G.1.K4 The student recognizes that similar figures have congruent angles, and their corresponding sides are proportional (2.4.K1h). 910.G.1.K6 The student recognizes and describes (2.4.K1g-h): a. <u>congruence of triangles using: Side-Side-Side (SSS), Angle-Side-Angle (ASA), Side-Angle-Side (SAS), and Angle-Angle-Side (AAS);</u> b. the ratios of the sides in special right triangles: 30°-60°-90° and 45°-45°-90°. 910.G.4.K4 ▲ The student finds and explains the relationship between the slopes of parallel and perpendicular lines (2.4.K1f),	Identifying errors in the logic and/or thinking of others is not required in KA standards.
Sp3. Construct and interpret representations of geometric objects. Include classical construction techniques and construction techniques supported by modern technologies. Include moving between two-dimensional representations and the three-dimensional objects they represent, such as in schematics, assembly instructions, perspective drawings and multiple views.	910.G.1.K1 The student recognizes and compares properties of two-and three-dimensional figures using concrete objects, <u>constructions</u> , drawings, appropriate terminology, and appropriate technology (2.4.K1h). 910.G.1.K3 The student recognizes and <u>describes the symmetries</u> (point, line, plane) that exist in three-dimensional figures (2.4.K1h). 910.G.3.K2 The student <u>recognizes a three-dimensional figure created by rotating a simple two-dimensional figure</u> around a fixed line (2.4.K1a), e.g., a rectangle rotated about one of its edges generates a cylinder; an isosceles triangle rotated about a fixed line that runs from the vertex to the midpoint of its base generates a cone. 910.G.3.K3 The student generates a two-dimensional representation of a three-dimensional figure (2.4.K1a).	

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<p>Sp4. Solve problems involving measurements. Include measurement (length, angle measure, area, surface area, and volume) of a variety of figures and shapes in two- and three-dimensions. Compute measurements using formulas and by decomposing complex shapes into simpler ones.</p>	<p>910.G.2.K4 The student states, recognizes, and applies formulas for (2.4.K1h) (\$): a. perimeter and area of squares, rectangle, and triangles; b. circumference and area of circles; volume of rectangular solids.</p> <p>910.G.2.K5 The student uses given measurement formulas to find perimeter, area, volume, and surface area of two- and three-dimensional figures (regular and irregular) (2.4.K1h).</p>	
<p>Sp5. Solve problems involving similar triangles and scale drawings. Include computing actual lengths, areas and volumes from a scale drawing and reproducing a scale drawing at a different scale.</p>	<p>910.A.4.A1 The student recognizes that various mathematical models can be used to represent the same problem situation. Mathematical models include: ... g. scale drawings to model large and small real-world objects ...</p> <p>910.G.1.K4 The student recognizes that <u>similar figures</u> have congruent angles, and their corresponding sides are proportional (2.4.K1h).</p> <p>910.G.2.K6 The student recognizes and applies properties of corresponding parts of <u>similar and congruent figures</u> to find measurements of missing sides (2.4.K1a).</p> <p>910.G.3.K1 The student describes and performs single and multiple transformations [reflection, rotation, translation, <u>reduction (contraction/shrinking), enlargement (magnification/growing)</u>] on two- and three-dimensional figures (2.4.K1a).</p>	
<p>Sp6. Apply properties of right triangles and right triangle trigonometry to solve problems. Include using the Pythagorean theorem and properties of special right triangles, and applying</p>	<p>910.G.1.K5 The student uses the Pythagorean Theorem to (2.4.K1h): a. determine if a triangle is a right triangle, b. find a missing side of a right triangle.</p>	

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<p>sine, cosine and tangent to determine lengths and angle measures of right triangles. Use right triangles and their properties to solve real-world problems. Limit angle measures to degrees.</p>	<p>910.G.1.K6 The student recognizes and describes (2.4.K1g-h):</p> <p>a. congruence of triangles using: Side-Side-Side (SSS), Angle-Side-Angle (ASA), Side-Angle-Side (SAS), and Angle-Angle-Side (AAS);</p> <p>b. <u>the ratios of the sides in special right triangles</u>: 30°-60°-90° and 45°-45°-90°.</p> <p>910.G.4.K5 The student uses the Pythagorean Theorem to find distance (may use the distance formula) (2.4.K1f).</p>	
<p>Coordinates Applying a coordinate system to Euclidean space connects algebra and geometry, resulting in powerful methods of analysis and problem solving.</p> <p>Just as the number line associates numbers with locations in one dimension, a pair of perpendicular axes associates pairs of numbers with locations in two dimensions. This correspondence between numerical coordinates and geometric points allows methods from algebra to be applied to geometry and vice versa. The solution set of an equation becomes a geometric curve, making visualization a tool for doing and understanding algebra. Geometric shapes can be described by equations, making algebraic manipulation into a tool for geometric understanding, modeling and proof.</p> <p>Coordinate geometry is a rich field for exploration. How does a geometric transformation such as a translation or reflection affect the coordinates of points? How is the geometric definition of a circle reflected in its equation?</p>		

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<p>Adding a third perpendicular axis associates three numbers with locations in three dimensions and extends the use of algebraic techniques to problems involving the three-dimensional world we live in.</p> <p>Connections to Shape, Quantity, Equations and Functions. Coordinates can be used to reason about shapes. In applications, coordinate values often have units (such as meters and bushels). A one-variable equation of the form $f(x) = g(x)$ may be solved in the coordinate plane by finding intersections of the curves $y = f(x)$ and $y = g(x)$.</p>		
Core Concepts		
CA. Locations in the plane or space can be specified by pairs or triples of numbers called coordinates.	Teacher Notes under G.4) Any point on the coordinate plane can be named with two numbers called coordinates.	Location and the terminology of ordered pairs are addressed in the Teacher Notes under G.4. Coordinates in 3-D space are not addressed in KA standards.
CB. Coordinates link algebra with geometry and allow methods in one domain to solve problems in the other.	<p>910.G.4.A2 The student translates between the written, numeric, <u>algebraic, and geometric representations</u> of a real-world problem (2.4.A1a-e) (\$),</p> <p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... d. <u>equations and inequalities to model numerical and geometric relationships</u> (1.4.K2c, 2.2.K3, 2.3.K1-2, 3.2.K7) (\$);</p>	

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<p>CC. The set of solutions to an equation in two variables forms a curve in the coordinate plane—such as a line, parabola, circle—and the solutions to systems of equations in two variables correspond to intersections of these curves.</p>	<p>910.A.3.A2 ▲ ■ The student interprets the meaning of the x- and y- intercepts, slope, and/or <u>points on and off the line on a graph</u> in the context of a real-world situation (2.4.A1e)</p> <p>910.G.4.K7 The student recognizes the equation $y = ax^2 + c$ as a parabola; represents and identifies characteristics of the parabola including opens upward or opens downward, steepness (wide/narrow), the vertex, maximum and minimum values, and line of symmetry; and sketches the graph of the parabola (2.4.K1f).</p> <p>910.G.4.K8 The student explains the relationship between the solution(s) to systems of equations and systems of inequalities in two unknowns and their corresponding graphs (2.4.K1f),</p> <p>910.A.2.K3 The student solves (2.4.K1d) (\$): ... c. ▲N systems of linear equations with two unknowns using integer coefficients and constants; ...</p>	
Core Skills		
<p>C1. Translate fluently between lines in the coordinate plane and their equations. Include predicting visual features of lines by inspection of their equations, determining the equation of the line through two given points, and determining the equation of the line with a given slope passing through a given point.</p>	<p>910.G.4.K3 The student calculates the slope of a line from a list of ordered pairs on the line and <u>explains how the graph of the line is related to its slope</u> (2.4.K1f).</p> <p>910.G.4.K6 ▲ The student recognizes the equation of a line and transforms the equation into slope-intercept form in order to identify the slope and y-intercept and <u>uses this information to graph the line</u> (2.4.K1f).</p>	
<p>C2. Identify the correspondence between parameters in common families of equations and the location and appearance of their</p>	<p>910.A.3.K6 ▲ The student recognizes how changes in the constant and/or slope within a linear function changes the appearance of a graph (2.4.K1f) (\$).</p>	<p>The KA standards do not explicitly address parameter changes in the equations of</p>

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<p>graphs. Include common families of equations—the graphs of $Ax + By = C$, $y = mx + b$ and $x = a$ are straight lines; the graphs of $y = a(x - h)^2 + k$ and $y = Ax^2 + Bx + C$ are parabolas; and the graph of $(x - h)^2 + (y - k)^2 = r^2$ is a circle.</p>	<p>910.G.4.K1 The student recognizes and examines two- and three-dimensional figures and their attributes <u>including the graphs of functions on a coordinate plane</u> using various methods including mental math, paper and pencil, concrete objects, and graphing utilities or other appropriate technology (2.4.K1f).</p>	<p>parabolas and circles and their effects on the graphs.</p>
<p>C3. Use coordinates to solve geometric problems. Include proving simple theorems algebraically, using coordinates to compute perimeters and areas for triangles and rectangles, finding midpoints of line segments, finding distances between pairs of points and determining when two lines are parallel or perpendicular.</p>	<p>910.G.4.K1 The student recognizes and <u>examines two- and three-dimensional figures and their attributes</u> including the graphs of functions <u>on a coordinate plane</u> using various methods including mental math, paper and pencil, concrete objects, and graphing utilities or other appropriate technology (2.4.K1f).</p> <p>910.G.4.K4 ▲ The student finds and explains the relationship between the slopes of parallel and perpendicular lines (2.4.K1f),</p> <p>910.G.4.K5 The student uses the Pythagorean Theorem to find distance (may use the distance formula) (2.4.K1f).</p>	<p>There is no requirement to use coordinates to find the midpoint of a line segment in KA standards.</p>
<p>Probability Probability assesses the likelihood of an event in a situation that involves randomness. It quantifies the degree of certainty that an event will happen as a number from 0 through 1. This number is generally interpreted as the relative frequency of occurrence of the event over the long run.</p> <p>The structure of a probability model begins by listing or describing the possible outcomes for a random situation (the sample space) and assigning probabilities based on an assumption about long-</p>		



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<p>run relative frequency. In situations such as flipping a coin, rolling a number cube, or drawing a card, it is reasonable to assume various outcomes are equally likely.</p> <p>Compound events constructed from these simple ones can be represented by tree diagrams and by frequency or relative frequency tables. The probabilities of compound events can be computed using these representations and by applying the additive and multiplicative laws of probability. Interpreting these probabilities relies on an understanding of independence and conditional probability, approachable through the analysis of two-way tables.</p> <p>Converting a verbally-stated problem into the symbols and relations of probability requires careful attention to words such as and, or, if, and all, and to grammatical constructions that reflect logical connections. This is especially true when applying probability models to real-world problems, where simplifying assumptions are also usually necessary in order to gain at least an approximate solution.</p> <p>Connections to Statistics and Expressions. Probability is the foundation for drawing valid conclusions from sampling or experimental data. Counting has an advanced connection with Expressions through Pascal's triangle and binomial expansions.</p>		
Core Concepts		

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PA. Probability models outcomes for situations in which there is inherent randomness, quantifying the degree of uncertainty in terms of relative frequency of occurrence.	910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... k. geometric models (spinners, targets, or number cubes), process models (concrete objects, pictures, diagrams, or coins), and tree diagrams to <u>model probability</u> (4.1.K1-3); l. <u>frequency tables</u> , bar graphs, line graphs, circle graphs, Venn diagrams, charts, tables, single and double stem-and-leaf plots, scatter plots, box-and-whisker plots, histograms, and matrices to organize and display data (4.2.K1, 4.2.K5-6) (\$); ...	
PB. The law of large numbers provides the basis for estimating certain probabilities by use of empirical relative frequencies.	910.D.1.A3 The student compares theoretical probability (expected results) with empirical probability (experimental results) of two independent and/or dependent events and understands that <u>the larger the sample size, the greater the likelihood that experimental results will match theoretical probability</u> (2.4.A1h).	
PC. The laws of probability govern the calculation of probabilities of combined events.	910.D.1. Probability – The student <u>applies probability theory</u> to draw conclusions, generate convincing arguments, make predictions and decisions, and analyze decisions including the use of concrete objects in a variety of situations.	

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	910.D.1.A2 The student uses theoretical or empirical probability of a simple or <u>compound event composed of two or more simple, independent events</u> to make predictions and analyze decisions about real-world situations including: <ul style="list-style-type: none"> a. work in economics, quality control, genetics, meteorology, and other areas of science (2.4.A1a); b. games (2.4.A1a); c. situations involving geometric models, e.g., spinners or dartboards (2.4.A1f). 	
PD. Interpreting probabilities contextually is essential to rational decision-making in situations involving randomness.	910.D.1.A4 <u>The student uses conditional probabilities of two dependent events in an experiment, simulation, or situation</u> to make predictions and analyze decisions.	
Core Skills		
P1. Compute theoretical probabilities by systematically counting points in the sample space. Make use of symmetry and equally likely outcomes. Include permutation and combination problems as long as small numbers are involved or technology is used, so that formulas are not required.		KA standards do not address systematic counting techniques.
P2. Interpret probabilities of compound events using concepts of independence and conditional probability. Include reading conditional probabilities from two-way tables.	910.D.1.K1 The student finds the probability of two independent events in an experiment, simulation, or situation (2.4.K1k) (\$). 910.D.1.K2 The student finds the conditional probability of two dependent events in an experiment, simulation, or situation (2.4.K1k).	

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<p>P3. Compute probabilities of compound events. Make use of the additive and multiplicative laws of probability, tree diagrams and frequency or relative frequency tables in real contexts. Do not emphasize fluency with the related formulas.</p>	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... k. geometric models (spinners, targets, or number cubes), process models (concrete objects, pictures, diagrams, or coins), and <u>tree diagrams to model probability</u> (4.1.K1-3); l. <u>frequency tables</u>, bar graphs, line graphs, circle graphs, Venn diagrams, charts, tables, single and double stem-and-leaf plots, scatter plots, box-and-whisker plots, histograms, and matrices to organize and display data (4.2.K1, 4.2.K5-6) (\$); ...</p> <p>910.D.1.A2 The student <u>uses</u> theoretical or empirical probability of a simple or <u>compound event</u> composed of two or more simple, independent events to <u>make predictions and analyze decisions</u> about real-world situations including: a. work in economics, quality control, genetics, meteorology, and other areas of science (2.4.A1a); b. games (2.4.A1a); c. situations involving geometric models, e.g., spinners or dartboards (2.4.A1f).</p>	

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<p>P4. Estimate probabilities empirically. Include using data from simulations carried out with technology to estimate probabilities.</p>	<p>910.D.1.A2 The student <u>uses</u> theoretical or <u>empirical probability</u> of a simple or compound event composed of two or more simple, independent events <u>to make predictions and analyze decisions</u> about real-world situations including: a. work in economics, quality control, genetics, meteorology, and other areas of science (2.4.A1a); b. games (2.4.A1a); c. situations involving geometric models, e.g., spinners or dartboards (2.4.A1f).</p>	<p>The CCSS do not list specific types of applications for probability.</p>
<p>P5. Identify and explain common misconceptions regarding probability. Include misconceptions about long-run versus short-run behavior of relative frequencies (the law of large numbers). Include attention to the use and misuse of probability in the media, especially in terms of interpreting charts and tables and in the contextual meaning of terms connected to probability, such as ‘odds’ or ‘risk.’</p>		<p>The misconceptions regarding probability are not addressed in KA standards.</p>
<p>P6. Adapt probability models to solve real-world problems. Include the use of conditional probability to assess subsets of data (e.g., what does the data say about males and females separately). Include the use of independence as a simplifying assumption (e.g., find the probability that two students both contract the disease this year).</p>	<p>910.D.1.K3 ▲ The student explains the relationship between probability and odds and computes one given the other (2.4.K1a,k). 910.D.1.K2 The student finds the conditional probability of two dependent events in an experiment, simulation, or situation (2.4.K1k). 910.D.1.A1 The student conducts an experiment or simulation with two dependent events; records the results in charts, tables, or graphs; and uses the results to generate convincing arguments, draw conclusions and make predictions (2.4.A1h-i).</p>	

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	<p>910.D.1.A2 The student uses theoretical or empirical probability of a simple or compound event composed of two or more simple, independent events to make predictions and analyze decisions about real-world situations including:</p> <ul style="list-style-type: none"> a. work in economics, quality control, genetics, meteorology, and other areas of science (2.4.A1a); b. games (2.4.A1a); c. situations involving geometric models, e.g., spinners or dartboards (2.4.A1f). <p>910.D.1.A3 The student compares theoretical probability (expected results) with empirical probability (experimental results) of two independent and/or dependent events and understands that the larger the sample size, the greater the likelihood that experimental results will match theoretical probability (2.4.A1h).</p> <p>910.D.1.A4 The student uses conditional probabilities of two dependent events in an experiment, simulation, or situation to make predictions and analyze decisions.</p>	
<p>Statistics Decisions or predictions are often based on data—numbers in context. These decisions or predictions would be easy if the data always sent a clear message, but the message is often obscured by variability in the data. Statistics provides tools for describing variability in data and for making informed decisions that take variability into account.</p> <p>Data are gathered, displayed, summarized, examined and interpreted to discover patterns. Data</p>		



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<p>can be summarized by a statistic measuring center, such as mean or median, and a statistic measuring spread, such as interquartile range or standard deviation. Different distributions can be compared numerically using these statistics or visually using plots. Which statistics to compare, and what the results of a comparison might mean, depend on the question to be investigated and the real-life actions to be taken.</p> <p>Randomization has two important uses in drawing statistical conclusions. First, collecting data from a random sample of a population makes it possible to draw valid conclusions about the whole population, taking variability into account. Second, randomly assigning individuals to different treatments allows a fair comparison of the effectiveness of those treatments. A statistically significant outcome is one that is unlikely to be due to chance and this can be evaluated only under the condition of randomness.</p> <p>In critically reviewing uses of statistics in public media and other reports, it is important to consider the study design, how the data were collected, and the analyses employed as well as the data summaries and the conclusions drawn.</p> <p>Connections to Probability, Functions and Modeling. Valid conclusions about a population depend on designed simulations or other statistical studies using random sampling or assignment and rely on probability for their interpretation. Functional models may be used to approximate data. If the</p>		

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<p>data are approximately linear, the relationship may be modeled with a trend line and the strength and direction of such a relationship may be expressed through a correlation coefficient. Technology facilitates the study of statistics by making it possible to simulate many possible outcomes in a short amount of time, and by generating plots, function models, trend lines and correlation coefficients.</p>		
Core Concepts		
<p>StA. Statistical methods take variability into account to support making informed decisions based on quantitative studies designed to answer specific questions.</p>		<p>KA standards do not include a description of statistical methods.</p>
<p>StB. Visual displays and summary statistics condense the information in data sets into usable knowledge.</p>	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... l. frequency tables, bar graphs, line graphs, circle graphs, Venn diagrams, charts, tables, single and double stem-and-leaf plots, scatter plots, box-and-whisker plots, histograms, and matrices to organize and display data (4.2.K1, 4.2.K5-6) (\$); m. Venn diagrams to sort data and show relationships (1.2.K2).</p>	

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	910.D.2.K1 The student organizes, displays, and reads quantitative (numerical) and qualitative (non-numerical) data in a clear, organized, and accurate manner including a title, labels, categories, and rational number intervals using these data displays (2.4.K1I): a. frequency tables and line plots; b. bar, line, and circle graphs; c. Venn diagrams or other pictorial displays; d. charts and tables; e. stem-and-leaf plots (single and double); f. scatter plots; g. box-and-whiskers plots; h. histograms.	
StC. Randomness is the foundation for using statistics to draw conclusions when testing a claim or estimating plausible values for a population characteristic.	910.D.2.A2 The student determines and describes appropriate data collection techniques (observations, surveys, or interviews) and <u>sampling techniques</u> (random sampling, samples of convenience, biased sampling, census of total population, or purposeful sampling) in a given situation.	While random sampling is listed among the possible sampling techniques in KA standards, there is no clear reference to the importance of randomness in the use of statistics.
StD. The design of an experiment or sample survey is of critical importance to analyzing the data and drawing conclusions.	910.D.2.K2 The student explains how the reader's bias, measurement errors, and display distortions can affect the interpretation of data. 910.D.2.A2 The student <u>determines and describes appropriate data collection techniques</u> (observations, surveys, or interviews) and <u>sampling techniques</u> (random sampling, samples of convenience, biased sampling, census of total population, or purposeful sampling) in a given situation.	KA standards address some possible ways the design of an experiment might influence the conclusions drawn but do not specifically require an understanding of the importance of an experiment's design to the conclusions that might be drawn from a statistical study.

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Core Skills		
<p>St1. Formulate questions that can be addressed with data. Identify the relevant data, collect and organize it to respond to the question. Include determining whether a question can best be addressed through a sample survey, randomized experiment or observational study. Include unbiased selection for a sample and randomization of assignment to treatment for an experiment.</p>	<p>8.D.4.A1 The student conducts an experiment or simulation with independent or dependent events including the use of concrete objects; records the results in a chart, table, or graph; and uses the results to draw conclusions and make predictions about future events (2.4.A1i-j).</p> <p>910.D.2.A2 The student determines and describes appropriate data collection techniques (observations, surveys, or interviews) and <u>sampling techniques</u> (random sampling, samples of convenience, biased sampling, census of total population, or purposeful sampling) in a given situation.</p>	
<p>St2. Use appropriate displays and summary statistics for data. Include univariate, bivariate, categorical and quantitative data. Include the thoughtful selection of measures of center and spread to summarize data.</p>	<p>910.A.4.K1 The student knows, explains, and uses mathematical models to represent and explain mathematical concepts, procedures, and relationships. Mathematical models include: ... l. frequency tables, bar graphs, line graphs, circle graphs, Venn diagrams, charts, tables, single and double stem-and-leaf plots, scatter plots, box-and-whisker plots, histograms, and matrices to organize and display data (4.2.K1, 4.2.K5-6) (\$); m. Venn diagrams to sort data and show relationships (1.2.K2).</p>	

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	<p>910.D.2.K1 The student organizes, displays, and reads quantitative (numerical) and qualitative (non-numerical) data in a clear, organized, and accurate manner including a title, labels, categories, and rational number intervals using these data displays (2.4.K1i):</p> <ul style="list-style-type: none"> a. frequency tables and line plots; b. bar, line, and circle graphs; c. Venn diagrams or other pictorial displays; d. charts and tables; e. stem-and-leaf plots (single and double); f. scatter plots; g. box-and-whiskers plots; h. histograms. <p>910.D.2.K3 The student calculates and explains the meaning of range, quartiles and interquartile range for a real number data set (2.4.K1a).</p> <p>910.D.2.A4 The student determines and explains the advantages and disadvantages of using each measure of central tendency and the range to describe a data set (2.4.K1i).</p>	
<p>St3. Interpret data displays and summaries critically; draw conclusions and develop recommendations. Include paying attention to the context of the data,</p>	<p>910.D.2.K4 ▲ The student explains the effects of outliers on the measures of central tendency (mean, median, mode) and range and interquartile range of a real number data set (2.4.K1a).</p>	<p>There is no emphasis in KA standards on the context of a data collection or statistical studies.</p>

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interpolating or extrapolating judiciously and examining the effects of extreme values of the data on summary statistics of center and spread. Include data sets that follow a normal distribution. Include observing and interpreting linear trends in bivariate quantitative data.	910.D.2.K6 The student compares and contrasts the dispersion of two given sets of data in terms of range and the shape of the distribution including (2.4.K1k): a. symmetrical (including normal), b. skew (left or right), c. bimodal, d. uniform (rectangular).	
St4. Draw statistical conclusions involving population means or proportions using sample data. Conclusions should be based on simulations or other informal techniques, rather than formulas.		Population and/or sample means are not addressed in the KA standards.
St5. Evaluate reports based on data. Include looking for bias or flaws in way the data were gathered or presented, as well as unwarranted conclusions, such as claims that confuse correlation with causation.	910.D.2.K2 The student explains how the reader's bias, measurement errors, and display distortions can affect the interpretation of data.	Recognition of the misleading uses of statistics is not addressed in KA standards.