Cobb County School District
2023-2024

8th Grade Mathematics Teaching & Learning Framework

Semester 1			Semester 2			
Unit 1 6 weeks	**Unit 2** 8 weeks	**Unit 3** 4 weeks	**Unit 4** 6 weeks	**Unit 5** 6 weeks	**Unit 6** 4 weeks	**Unit 7** 2 weeks
Investigating Linear Expressions, Equations, and Inequalities in One Variable **8.PAR.3**	**Modeling Linear Relationships and Functions** **8.PAR.4** **8.FGR.5**	**Investigating Data & Statistical Reasoning** **8.FGR.6**	**Real-Life Phenomena Explored Through Systems of Linear Equations** **8.FGR.7**	**Irrationals, Integer Exponents and Scientific Notation** **8.NR.1-2**	**Exploring Geometric Relationships** **8.GSR.8**	**Culminating Capstone Unit**
8.PAR.3.6 (Literal equations) **8.PAR.3.1** (Expressions) **8.PAR.3.2** (Solving equations) **8.PAR.3.3** (Create and solve equations and inequalities) **8.PAR.3.4** (Justify solving equations with properties) **8.PAR.3.5** (Solve equations and inequalities with coefficients as letters)	**8.PAR.4.1** ($y = mx + b$ and $y = mx$) **8.PAR.4.2** (Graphing lines) **8.FGR.5.1** (Functions) **8.FGR. 5.2** (Linear and non-linear functions) **8.FGR.5.3** (Domain) **8.FGR.5.4** (Compare properties) **8.FGR.5.5** (Equation forms) **8.FGR.5.6** (Equivalent forms) **8.FGR.5.7** (Construct a linear function) **8.FGR.5.8** (Rate of change and initial value) **8.FGR.5.9** (Characteristics)	**8.FGR.6.1** (Line of best fit) **8.FGR.6.2** (Solving problems using linear model equation) **8.FGR.6.3** (Meaning of predicted slope and intercept of linear model) **8.FGR.6.4** (Line of best fit questions and inferences)	**8.FGR.7.1** (Interpret and solve problems with two equations and two variables) **8.FGR.7.2** (Intersection points of linear equations) **8.FGR.7.3** (Solve systems by graphing) **8.FGR.7.4** (Solve systems algebraically) **8.FGR.7.5** (Parallel and perpendicular line equations)	**8.NR.1.1** (Rational and irrational numbers) **8.NR.1.2** (Locate irrational numbers on number line) **8.NR.2.1** (Integer exponents) **8.NR.2.2** (Square roots and cube roots) **8.NR.2.3** (Scientific notation) **8.NR.2.4** (Add, subtract, multiply, and divide with scientific notation numbers)	**8.GSR.8.1** (Proof and converse of Pythagorean Theorem) **8.GSR.8.2** (Apply Pythagorean Theorem) **8.GSR.8.3** (Distance between two points on graph) **8.GSR.8.4** (Volume of cone, cylinder, and sphere)	**All Standards**

Units contain tasks that depend upon the concepts addressed in earlier units. Mathematical standards are interwoven and should be addressed throughout the year in as many different units and tasks as possible in order to stress the natural connections that exist among mathematical topics.

The Framework for Statistical Reasoning, Mathematical Modeling Framework, and the K-12 Mathematical Practices should be taught throughout the units.

Key for Course Standards: PAR: Patterning & Algebraic Reasoning, FGR: Functional & Graphical Reasoning, GSR: Geometric & Spatial Reasoning, NR: Numerical Reasoning

MATHEMATICS

Enhanced 8th/Algebra Teaching & Learning Framework

Semester 1				Semester 2			
Unit 1 5 weeks	**Unit 2** 2 weeks	**Unit 3** 2 weeks	**Unit 4** 9 weeks	**Unit 5** 6 weeks	**Unit 6** 4 weeks	**Unit 7** 6 weeks	**Unit 8** 2 weeks
Modeling Linear Functions **8.PAR.3-4** **A.FGR.2,5**	**Analyzing Linear Inequalities** **8.FGR.7** **A.PAR.4**	**Investigating Rational and Irrational Numbers** **8.NR.1-2** **A.NR.5**	**Modeling and Analyzing Quadratic Functions** **A.PAR.6** **A.FGR.7**	**Modeling and Analyzing Exponential Expressions & Equations** **A.PAR.8** **A.FGR.9**	**Investigating Data** **8.FGR.6** **A.DSR.10**	**Algebraic Connections to Geometric Concepts** **8.GSR.8** **A.GSR.3**	**Culminating Capstone Unit**
8.PAR.3.1-3.6 (Expressions, linear equations & inequalities) **8.PAR.4.1-4.2** ($y = mx$ and $y = mx + b$) **8.FGR.5.1-5.9** (Properties of functions) **A.FGR.2.1** (Arithmetic sequences) **A.FGR.2.2-2.5** (Formal notation and characteristics of linear and non-linear functions)	**8.FGR.7.1-7.5** (Systems of linear equations) **A.PAR.4.1** (Create, solve, and graph linear inequalities) **A.PAR.4.2** (Constraints of linear inequalities) **A.PAR.4.3** (Systems of linear inequalities)	**8.NR.1.1-1.2** (Rational vs. irrational) **8.NR.2.1-2.4** (Using & applying integer exponents) **A.NR.5.1** (Expressions involving radicals) **A.NR.5.2** (Explain irrational sums and products)	**A.PAR.6.1** (Interpret quadratic expressions) **A.PAR.6.2** (Rewrite quadratic expressions) **A.PAR.6.3** (Create and solve quadratic equations) **A.PAR.6.4** (Constraints of quadratic equations) **A.FGR.7.1** (Build and evaluate functions) **A.FGR.7.2** (Transformations) **A.FGR.7.3** (Analyze characteristics of quadratic functions) **A.FGR.7.4** (Domain and range) **A.FGR.7.5** (Rewrite quadratic functions to find max/min) **A.FGR.7.6** (Create and graph quadratic functions) **A.FGR.7.7** (Average rate of change) **A.FGR.7.8** (Write a quadratic function for different properties) **A.FGR.7.9** (Compare functions represented differently)	**A.PAR.8.1** (Interpret exponential expressions) **A.PAR.8.2** (Create exponential equations in one variable) **A.PAR.8.3** (Create exponential equations in two variables) **A.PAR.8.4** (Constraints of exponential equations) **A.FGR.9.1** (Build and evaluate functions) **A.FGR.9.2** (Graph and analyze characteristics of exponential functions) **A.FGR.9.3** (Transformations) **A.FGR.9.4** (Geometric sequences) **A.FGR.9.5** (Compare functions represented differently)	**A.DSR.10.1** (Compare center and variability with appropriate statistics) **A.DSR.10.2** (Interpret shape, center, and variability) **8.FGR.6.1** (Scatterplots & line of best fit) **A.DSR.10.3** (Represent data on a scatter plot) **8.FGR.6.2 & 6.3** (Bivariate data and slope) **A.DSR.10.4** (Interpret slope and y-intercept of linear model) **8.FGR.6.4** (Graphical displays) **A.DSR.10.5-7** (Calculating line of best fit and r)	**8.GSR.8.1-8.3** (Apply the Pythagorean Theorem) **A.GSR.3.1** (Solve problems with slope, parallel and perpendicular lines, area, and perimeter) **A.GSR.3.2** (Apply distance formula, midpoint formula, and slope to solve problems) **8.GSR.8.4** (Volume cones, cylinders, spheres)	**All standards**

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The Framework for Statistical Reasoning, Mathematical Modeling Framework, and the K-12 Mathematical Practices should be taught throughout the units.

Key for Course Standards: MP: Mathematical Practices, MM: Mathematical Modeling, NR: Numerical Reasoning, FGR: Functional & Graphical Reasoning, AGR: Algebraic & Geometric Reasoning, GSR: Geometric & Spatial Reasoning, PAR: Patterning & Algebraic Reasoning, DSR: Data & Statistical Reasoning

GEORGIA'S K-12 MATHEMATICS STANDARDS 2021

Governor Kemp and Superintendent Woods are committed to the best set of academic standards for Georgia's students – laying a strong foundation of the fundamentals, ensuring age- and developmentally appropriate concepts and content, providing instructional supports to set our teachers up for success, protecting and affirming local control and flexibility regarding the use of mathematical strategies and methods, and preparing students for life. These Georgia-owned and Georgia-grown standards leverage the insight, expertise, experience, and efforts of thousands of Georgians to deliver the very best educational experience for Georgia's 1.7 million students.

In August 2019, Governor Brian Kemp and State School Superintendent Richard Woods announced the review and revision of Georgia's K-12 mathematics standards. Georgians have been engaged throughout the standards review and revision process through public surveys and working groups. In addition to educator working groups, surveys, and the Academic Review Committee, Governor Kemp announced a new way for Georgians to provide input on the standards: the Citizens Review Committee, a group composed of students, parents, business and community leaders, and concerned citizens from across the state. Together, these efforts were undertaken to ensure Georgians will have buy-in and faith in the process and product.

The Citizens Review Committee provided a charge and recommendations to the working groups of educators who came together to craft the standards, ensuring the result would be usable and friendly for parents and students in addition to educators. More than 14,000 Georgians participated in the state's public survey from July through September 2019, providing additional feedback for educators to review. The process of writing the standards involved more than 200 mathematics educators -- from beginning to veteran teachers, representing rural, suburban, and metro areas of our state.

Grade-level teams of mathematics teachers engaged in deep discussions; analyzed stakeholder feedback; reviewed every single standard, concept, and skill; and provided draft recommendations. To support fellow mathematics teachers, they also developed learning progressions to show when key concepts were introduced and how they progressed across grade levels, provided examples, and defined age/developmentally appropriate expectations.

These teachers reinforced that strategies and methods for solving mathematical problems are classroom decisions -- not state decisions -- and should be made with the best interest of the individual child in mind. These recommended revisions have been shared with the Academic Review Committee, which is composed of postsecondary partners, age/development experts, and business leaders, as well as the Citizens Review Committee, for final input and feedback.

Based on the recommendation of Superintendent Woods, the State Board of Education will vote to post the draft K-12 mathematics standards for public comment. Following public comment, the standards will be recommended for adoption, followed by a year of teacher training and professional learning prior to implementation.

Use of Mathematical Strategies and Methods & Affirming Local Control

These standards preserve and affirm local control and flexibility regarding the use of the “standard algorithm” and other mathematical strategies and methods. Students have the right to use any strategy that produces accurate computations, makes sense, and is appropriate for their level of understanding.

Therefore, the wording of these standards allows for the “standard algorithm” as well as other cognitive strategies deemed developmentally appropriate for each grade level. Revised state tests will not measure the students’ use of specific mathematical strategies and methods, only whether students understand the key mathematical skills and concepts in these standards.

Teachers are afforded the flexibility to support the individual needs of their students. It is critical that teachers and parents remain partners to help each child grow to become a mathematically literate citizen.

Georgia's K-12 Mathematics Standards – 2021
Mathematics Big Ideas and Learning Progressions, 6-8

Mathematics Big Ideas, 6-8

<table>
<tr><th>5</th><th>6</th><th>7</th><th>8</th><th>HS
Algebra: Concepts & Connections</th><th>HS
Geometry: Concepts & Connections</th></tr>
<tr><td colspan="6">MATHEMATICAL PRACTICES & MODELING</td></tr>
<tr><td colspan="6">DATA & STATISTICAL REASONING</td></tr>
<tr><td colspan="6">NUMERICAL REASONING (NR)</td></tr>
<tr><td colspan="6">PATTERNING & ALGEBRAIC REASONING (PAR)</td></tr>
<tr><td colspan="3"></td><td colspan="3">FUNCTIONAL & GRAPHICAL REASONING (FGR)</td></tr>
<tr><td colspan="6">GEOMETRIC & SPATIAL REASONING (GSR)</td></tr>
<tr><td colspan="2"></td><td>PROBABILITY REASONING (PR)</td><td colspan="2"></td><td>PROBABILISTIC REASONING (PR)</td></tr>
</table>

6-8 MATHEMATICS: LEARNING PROGRESSIONS

Key Concepts	5	6	7	8	HS Algebra: Concepts & Connections	HS Geometry: Concepts & Connections
			NUMERICAL REASONING			
Numbers (rational numbers and irrational numbers)	• Multi-digit whole numbers • Fractions with unlike denominators • Fractions greater than 1 • Decimal numbers to thousandths • Powers of 10 to 10^3	• Rational numbers as a concept ○ Integers ○ Fractions ○ Decimal numbers	• All rational numbers • Simple probability	• All rational numbers • Scientific notation • Numerical expressions with integer exponents • Use appropriate counting strategies to approximate rational and irrational numbers (radicals) on a number line	• All rational numbers • Operations with radicals	• All numbers in The Real Number System
Computational Fluency	• Add & subtract fractions with unlike denominators • Add and subtract decimal numbers to the hundredths place • Multiply & divide multi-digit whole numbers • Multiply fractions and whole numbers • Divide unit fractions and whole numbers • Reason about multiplying by a fraction >, <, or = 1	• All operations with whole numbers, fractions, and decimal numbers • Write & evaluate numerical expressions • Convert fractions with denominators of 2, 4, 5 and 10 to the decimal notation	• Operations with rational numbers • Rational numbers • Convert fractions with all denominators to decimal numbers	• Operations with scientific notation • Scientific notation in real situations seen in everyday life • Expressions with integer exponents	• Operations with real numbers (rational and irrational) • Multiplication of irrational numbers	
Comparisons	• Decimal fractions to thousandths place • Fractions greater than 1	• Integers • Unit rates • Ratios • Numerical data distributions • Measures of variation • Absolute value • Display and analyze categorical and quantitative (numerical) data	• Rational numbers • Probabilities • Random sampling	• Rational and irrational numbers (radicals) • Compare proportional relationships presented in different ways	• Rate of change (slope) • Intercept • Distributions of two or more data sets	

6-8 MATHEMATICS: LEARNING PROGRESSIONS

Key Concepts	5	6	7	8	HS Algebra: Concepts & Connections	HS Geometry: Concepts & Connections
PATTERNING & ALGEBRAIC REASONING						
Patterns	• Generate two numerical patterns from a given rule • Identify relationships using a table	• Greatest common factor & least common multiple	• Constant of proportionality	• Integer exponents • Perfect squares and perfect cubes	• Arithmetic sequences • Geometric sequences	
Expressions	**Numerical Reasoning** • Simple numerical expressions involving whole numbers with or without grouping symbols • Express fractions as division problems	• Write, analyze, and evaluate numerical and algebraic expressions • Identify, generate, and evaluate algebraic expressions • Identify like terms in an algebraic expression	• Add, subtract, factor & expand linear expressions • Rewrite expressions • Fluency with combining like terms in an algebraic expression • Linear expressions with rational coefficients	• Expressions with integer exponents • Linear expressions • Operations with algebraic expressions	• Exponential expressions • Quadratic expressions	• Expressions of varying degrees • Add, subtract, multiply single variable polynomials • Adding, Subtracting and Multiplying Polynomials • Factoring and expanding polynomials
Variable Equations & Inequalities		• Write and solve one-step equations & inequalities	• Construct & solve multi-step algebraic equations and inequalities	• Analyze and solve linear equations and inequalities	• Exponential equations • Quadratic equations • Equations of parallel and perpendicular lines • Analyze and solve linear inequalities	• Equations involving geometric measurement
Ratios & Rates		**Numerical Reasoning with ratios and rates:** • Concept of ratio and rate • Equivalent ratios, percentages, unit rates • Convert within measurement systems	• Compute unit rates associated with ratios of fractions • Determine unit rates	• Interpret unit rate as the slope of a graph	• Convert units and rates given a conversion factor	• Side ratios of similar triangles • Trigonometric ratios
Proportional Relationships			• Use proportional relationships • Solve multi-step ratio and percent problems • Scale drawings of geometric figures • Use similar triangles to explain slope			
Graphing	• Plot order pairs in first quadrant	• Plot order pairs in all four quadrants • Show rational numbers on a number line • Draw polygons on a coordinate grid • Find the side length of a polygon graphed on the coordinate plane (same x- or y- coordinate)	• Proportional relationships	• Linear functions • Comparing linear and non-linear functions • Systems of linear equations (including parallel and perpendicular) • Linear inequalities • Analyze data distributions	• Linear functions with function notation • Exponential functions • Quadratic functions • Systems of linear inequalities	• Equations of circles in standard form

6-8 MATHEMATICS: LEARNING PROGRESSIONS

Key Concepts	5	6	7	8	HS Algebra: Concepts & Connections	HS Geometry: Concepts & Connections
FUNCTIONAL & GRAPHICAL REASONING						
Function Families				• Linear functions • Line of best fit	• Linear functions with function notation • Parent graphs of function families • Exponential functions • Quadratic functions	• Function notation to represent transformations
GEOMETRIC & SPATIAL REASONING						
Shapes & Properties	• Classify polygons based on geometric properties		• Measure angles using non-standard and standard tools • Write & solve equations using supplementary, complementary, vertical, and adjacent angles	• Introduction to Pythagorean Theorem and the converse		• Develop and use precise definitions to prove theorems and solve geometric problems • Prove slope criteria for parallel and perpendicular lines • Transform polygons using rotations, reflections, dilations, and translations. • Congruence and trans-formations • Triangle congruence • Use congruence to prove relationships in geometric figures • Similarity and dilations • Similar triangles • Use similarity to prove relationships in geometric figures • Formal proofs & theorems about triangles • Trigonometric ratios (Sin, Cos, & Tan)

6-8 MATHEMATICS: LEARNING PROGRESSIONS

Key Concepts	5	6	7	8	HS Algebra: Concepts & Connections	HS Geometry: Concepts & Connections
GEOMETRIC & SPATIAL REASONING (cont.)						
Geometric Measurement	• Volume of right rectangular prisms	• Area of triangles, quadrilaterals, and polygons • Surface area • Volume of right rectangular prisms with fractional edge lengths	• Relationship between parts of a circle • Area & circumference of a circle • Area and surface area of figures decomposed into triangles, quadrilaterals & circles • Volume of cubes, right prisms & cylinders	• Pythagorean Theorem to determine distance between two points • Volume of cones, cylinders, and spheres	• Use distance formula, midpoint formula, and slope to calculate perimeter and area of triangles and quadrilaterals	• Volumes of prisms, cones, cylinders, pyramids, and spheres • Approximate volumes of irregular objects • Approximate density of irregular objects
PROBABILITY REASONING						
Probability			• Represent probability • Approximate probability • Develop probability models (uniform & not uniform) • Find probabilities of simple events			• Categorical data & two-way frequency tables • Interpret probabilities in context

8th Grade

The eight standards listed below are the key content competencies students will be expected to master in eighth grade. Additional clarity and details are provided through the classroom-level learning objectives and evidence of student learning details for each grade-level standard found on subsequent pages of this document. As teachers are planning instruction and assessing mastery of the content at the grade level, the focus should remain on the key competencies listed in the table below.

EIGHTH GRADE STANDARDS
8.MP: **Display perseverance and patience in problem-solving. Demonstrate skills and strategies needed to succeed in mathematics, including critical thinking, reasoning, and effective collaboration and expression. Seek help and apply feedback. Set and monitor goals.**
8.NR.1: **Solve problems involving irrational numbers and rational approximations of irrational numbers to explain realistic applications.**
8.NR.2: **Solve problems involving radicals and integer exponents including relevant application situations; apply place value understanding with scientific notation and use scientific notation to explain real phenomena.**
8.PAR.3: **Create and interpret expressions within relevant situations. Create, interpret, and solve linear equations and linear inequalities in one variable to model and explain real phenomena.**
8.PAR.4: **Show and explain the connections between proportional and non-proportional relationships, lines, and linear equations; create and interpret graphical mathematical models and use the graphical, mathematical model to explain real phenomena represented in the graph.**
8.FGR.5: **Describe the properties of functions to define, evaluate, and compare relationships, and use functions and graphs of functions to model and explain real phenomena.**
8.FGR.6: **Solve practical, linear problems involving situations using bivariate quantitative data.**
8.FGR.7: **Justify and use various strategies to solve systems of linear equations to model and explain realistic phenomena.**
8.GSR.8: **Solve contextual, geometric problems involving the Pythagorean Theorem and the volume of geometric figures to explain real phenomena.**

8TH Grade

NUMERICAL REASONING *– rational and irrational numbers, decimal expansion, integer exponents, square and cube roots, scientific notation*

8.NR.1: Solve problems involving irrational numbers and rational approximations of irrational numbers to explain realistic applications.

	Expectations	Evidence of Student Learning (not all inclusive; see Grade Level Overview for more details)			
8.NR.1.1	Distinguish between rational and irrational numbers using decimal expansion. Convert a decimal expansion which repeats eventually into a rational number.	***Strategies and Methods*** • Students should be provided with experiences to use numerical reasoning when describing decimal expansions. • Students should be able to classify real numbers as rational or irrational. • Students should know that when a square root of a positive integer is not an integer, then it is irrational. • Students should use prior knowledge about converting fractions to decimals learned in 6th and 7th grade to connect changing decimal expansion of a repeating decimal into a fraction and a fraction into a repeating decimal. • Emphasis is placed on how all rational numbers can be written as an equivalent decimal. The end behavior of the decimal determines the classification of the number.	***Age/Developmentally Appropriate*** • This specific example is limited to the tenths place; however, the concept for this grade level extends to the hundredths place.	***Terminology*** • Rational numbers are those with decimal expansions that terminate in zeros or eventually repeat. • Irrational numbers are non-terminating, non-repeating decimals.	***Example*** • Change $0.\overline{4}$ to a fraction 1. Let x = 0.4444444 … 2. Multiply both sides so that the repeating digits will be in front of the decimal. In this example, one digit repeats so both sides are multiplied by 10, giving $10x$ = 4.4444444 … 3. Subtract the original equation from the new equation. $10x$ = 4.4444444 … x = 0.44444 … $9x = 4$ 4. Solve the equation to determine the equivalent fraction. $9x = 4$ $x = 4/9$
8.NR.1.2	Approximate irrational numbers to compare the size of irrational numbers, locate them approximately on a number line, and estimate the value of expressions.	***Strategies and Methods*** • Students should use visual models and numerical reasoning to approximate irrational numbers.	***Example*** • By estimating the decimal expansion of $\sqrt{17}$, show that $\sqrt{17}$ is between 4 and 5 and closer to 4 on a number line.		

8.NR.2: Solve problems involving radicals and integer exponents including relevant application situations; apply place value understanding with scientific notation and use scientific notation to explain real phenomena.

Expectations		Evidence of Student Learning (not all inclusive; see Grade Level Overview for more details)		
8.NR.2.1	Apply the properties of integer exponents to generate equivalent numerical expressions.	***Strategies and Methods*** ● Students should use numerical reasoning to identify patterns associated with properties of integer exponents. ● The following properties should be addressed: product rule, quotient rule, power rule, power of product rule, power of a quotient rule, zero exponent rule, and negative exponent rule.		***Example*** $3^2 \times 3^{(-5)} = 3^{(-3)} = \frac{1}{(3^3)} = \frac{1}{27}$
8.NR.2.2	Use square root and cube root symbols to represent solutions to equations. Recognize that $x^2 = p$ (where p is a positive rational number and $\|x\| \le 25$) has two solutions and $x^3 = p$ (where p is a negative or positive rational number and $\|x\| \le 10$) has one solution. Evaluate square roots of perfect squares ≤ 625 and cube roots of perfect cubes ≥ -1000 and ≤ 1000.	***Strategies and Methods*** ● Students should be able to find patterns within the list of square numbers and then with cube numbers. ● Students should be able to recognize that squaring a number and taking the square root of a number are inverse operations; likewise, cubing a number and taking the cube root are inverse operations.	***Fundamentals*** ● Equations should include rational numbers such as $x^2 = \frac{1}{4}$.	***Example*** ● $\sqrt{64} = \sqrt{8^2} = 8$ and $\sqrt[3]{(5^3)} = 5$. Since $\sqrt{p}$ is defined to mean the positive solution to the equation $x^2 = p$ (when it exists). It is not mathematically correct to say $\sqrt{64} = \pm 8$ (as is a common misconception). In describing the solutions to $x^2 = 64$, students should write $x = \pm\sqrt{64} = \pm 8$.
8.NR.2.3	Use numbers expressed in scientific notation to estimate very large or very small quantities, and to express how many times as much one is than the other.	***Strategies and Methods*** ● Students should use the magnitude of quantities to compare numbers written in scientific notation to determine how many times larger (or smaller) one number written in scientific notation is than another. ● Students should have opportunities to compare numbers written in scientific notation in contextual, mathematical problems, including scientific situations.		***Example*** ● Estimate the population of the United States as 3×10^8 and the population of the world as 7×10^9 and determine that the world population is more than 20 times larger.
8.NR.2.4	Add, subtract, multiply and divide numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Interpret scientific notation that has been generated by technology (e.g., calculators or online technology tools).	***Fundamentals*** ● Students should use place value reasoning which supports the understanding of digits shifting to the left or right when multiplied by a power of 10.	***Strategies and Methods*** ● Students combine knowledge of integer exponent rules and scientific notation to perform operations with numbers expressed in scientific notation. ● Students should solve realistic problems involving scientific notation.	

PATTERNING & ALGEBRAIC REASONING – *expressions, linear equations, and inequalities*

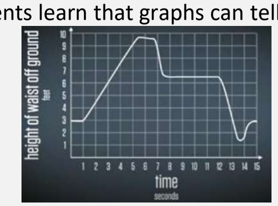
8.PAR.3: Create and interpret expressions within relevant situations. Create, interpret, and solve linear equations and linear inequalities in one variable to model and explain real phenomena.

Expectations		Evidence of Student Learning (not all inclusive; see Grade Level Overview for more details)	
8.PAR.3.1	Interpret expressions and parts of an expression, in context, by utilizing formulas or expressions with multiple terms and/or factors.	***Fundamentals*** • Students should build on their prior knowledge of understanding the parts of an expression to extend their understanding to more complex expressions with multiple terms and/or factors.	***Terminology*** • Parts of an expression include terms, factors, coefficients, and operations.
8.PAR.3.2	Describe and solve linear equations in one variable with one solution (x = a), infinitely many solutions (a = a), or no solutions (a = b). Show which of these possibilities is the case by successively transforming the given equation into simpler forms, until an equivalent equation of the form x = a, a = a, or a = b results (where a and b are different numbers).	***Strategies and Methods*** • Students should use algebraic reasoning in their descriptions of the solutions to linear equations. • Building upon skills from Grade 7, students combine like terms on the same side of the equal sign and use the distributive property to simplify the equation when solving. Emphasis in this standard is also on using rational coefficients. Solutions of certain equations may elicit infinitely many or no solutions.	
8.PAR.3.3	Create and solve linear equations and inequalities in one variable within a relevant application.	***Strategies and Methods*** • Students should use algebraic reasoning in their descriptions of the solutions to linear equations. • Include linear equations and inequalities with rational number coefficients and whose solutions require expanding expressions using the distributive property and collecting like terms.	
8.PAR.3.4	Using algebraic properties and the properties of real numbers, justify the steps of a one-solution equation or inequality.	***Strategies and Methods*** • Students should justify their own steps, or if given two or more steps of an equation, explain the progression from one step to the next using properties.	
8.PAR.3.5	Solve linear equations and inequalities in one variable with coefficients represented by letters and explain the solution based on the contextual, mathematical situation.	***Strategies and Methods*** • Students should use algebraic reasoning to solve linear equations and inequalities in one variable.	***Example*** • Given $ax + 3 = 7$, solve for x.
8.PAR.3.6	Use algebraic reasoning to fluently manipulate linear and literal equations expressed in various forms to solve relevant, mathematical problems.	***Strategies and Methods*** • To achieve fluency, students should be able to choose flexibly among methods and strategies to solve mathematical problems accurately and efficiently. • Students should rearrange formulas to highlight a quantity of interest using the same reasoning as in solving equations. Interpret and explain the results.	***Example*** • Find the radius given the formula $V = \pi r^2 h$ by rearranging the equation to solve for the radius, r.

8.PAR.4: Show and explain the connections between proportional and non-proportional relationships, lines, and linear equations; create and interpret graphical mathematical models and use the graphical, mathematical model to explain real phenomena represented in the graph.				
Expectations		**Evidence of Student Learning** (not all inclusive; see Grade Level Overview for more details)		
8.PAR.4.1	Use the equation $y = mx$ (proportional) for a line through the origin to derive the equation $y = mx + b$ (non-proportional) for a line intersecting the vertical axis at b.	***Fundamentals*** ● Students should be given opportunities to explore how an equation in the form $y = mx + b$ is a translation of the equation $y = mx$. ● In Grade 7, students had multiple opportunities to build a conceptual understanding of slope as they made connections to unit rate and analyzed the constant of proportionality for proportional relationships. ● Students should be given opportunities to explore and generalize that two lines with the same slope but different intercepts, are also translations of each other. ● Students should be encouraged to attend to precision when discussing and defining b (i.e., b is not the intercept; rather, b is the y-coordinate of the y-intercept). Students must understand that the x-coordinate of the y-intercept is always 0.	***Strategies and Methods*** ● Students should be given the opportunity to explore and discover the effects on a graph as the value of the slope and y-intercept changes using technology.	***Example*** ● The business model for a company selling a service with no flat cost charges \$3 per hour. What would the equation be as a proportional equation? If the company later decides to charge a flat rate of \$10 for each transaction with the same per hour cost, what would be the new equation? How do these two equations compare when analyzed graphically? What is the same? What is different? Why?
8.PAR.4.2	Show and explain that the graph of an equation representing an applicable situation in two variables is the set of all its solutions plotted in the coordinate plane.	***Strategies and Methods*** ● Students should use algebraic reasoning to show and explain that the graph of an equation represents the set of all its solutions. ● Students continue to build upon their understanding of proportional relationships, using the idea that one variable is conditioned on another. ● Students should relate graphical representations to contextual, mathematical situations. ● Students should use tables to relate solution sets to graphical representations on the coordinate plane.		

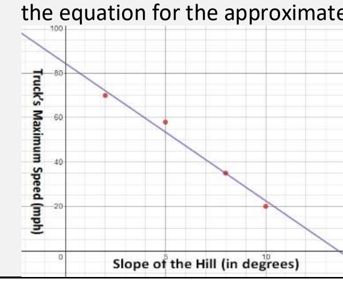
FUNCTIONAL & GRAPHICAL REASONING *–relate domain to linear functions, rate of change, linear vs. nonlinear relationships, graphing linear functions, systems of linear equations, parallel and perpendicular lines*

8.FGR.5: Describe the properties of functions to define, evaluate, and compare relationships, and use functions and graphs of functions to model and explain real phenomena.

Expectations		Evidence of Student Learning **(not all inclusive; see Grade Level Overview for more details)**
8.FGR.5.1	Show and explain that a function is a rule that assigns to each input exactly one output.	***Strategies and Methods*** ● Students should be able to use algebraic reasoning when formulating an explanation or justification regarding whether or not a relationship is a function or not a function. ● Describe the graph of a function as the set of ordered pairs consisting of an input and the corresponding output.
8.FGR.5.2	Within realistic situations, identify and describe examples of functions that are linear or nonlinear. Sketch a graph that exhibits the qualitative features of a function that has been described verbally.	***Strategies and Methods*** ● Students should be able to model practical situations using graphs and interpret graphs based on the situations. ● Students should model functions that are nonlinear and explain, using precise mathematical language, how to tell the difference between linear (functions that graph into a straight line) and nonlinear functions (functions that do not graph into a straight line). ● Students should analyze a graph by determining whether the function is increasing or decreasing, linear or non-linear. ● Students should have the opportunity to explore a variety of graphs including time/distance graphs and time/velocity graphs. **Examples** ● The function $A = s^2$ giving the area of a square as a function of its side length is not linear because its graph contains the points (1,1), (2,4) and (3,9), which are not on a straight line. ● Examples such as this can be used to help students learn that graphs can tell stories. 
8.FGR.5.3	Relate the domain of a linear function to its graph and where applicable to the quantitative relationship it describes.	***Example*** ● If the function h(n) gives the number of hours it takes a person to assemble n engines in a factory, then the set of positive integers would be an appropriate domain for the function.
8.FGR.5.4	Compare properties (rate of change and initial value) of two functions used to model an authentic situation each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).	***Example*** ● Given a linear function represented by a table of values and a linear function represented by an algebraic expression, determine which function has the greater rate of change.
8.FGR.5.5	Write and explain the equations $y = mx + b$ (slope-intercept form), $Ax + By = C$ (standard form), and $(y - y_1) = m(x-x_1)$ (point-slope form) as defining a linear function whose graph is a straight line to reveal and explain different properties of the function.	***Strategies and Methods*** ● Students should be able to rewrite linear equations written in different forms depending on the given situation. ***Terminology*** ● Forms of linear equations: standard, slope-intercept, and point-slope forms.

8.FGR.5.6	Write a linear function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.	***Strategies and Methods*** ● Problems should be practical and applicable to represent real situations, providing a purpose for analyzing equivalent forms of an expression. ● Rewrite a function expressed in standard form to slope-intercept form to make sense of a meaningful situation.	
8.FGR.5.7	Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x,y) values, including reading these from a table or from a graph.	***Strategies and Methods*** ● This learning objective also includes verbal descriptions and scenarios of equations, tables, and graphs.	
8.FGR.5.8	Explain the meaning of the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.	***Strategies and Methods*** ● This learning objective also includes verbal descriptions and scenarios of equations, tables, and graphs.	
8.FGR.5.9	Graph and analyze linear functions expressed in various algebraic forms and show key characteristics of the graph to describe applicable situations.	***Strategies and Methods*** ● Use verbal descriptions, tables and graphs created by hand and/or using technology.	***Terminology*** ● Various forms of linear functions include standard, slope-intercept, and point-slope forms. ● Key features include rate of change (slope), intercepts, strictly increasing or strictly decreasing, positive, negative, and end behavior.

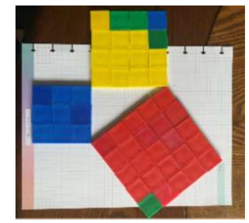
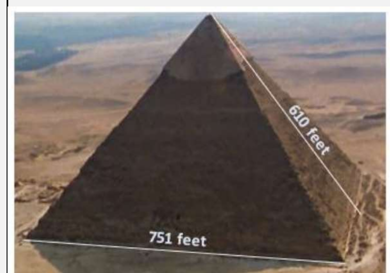
8.FGR.6: Solve practical, linear problems involving situations using bivariate quantitative data.

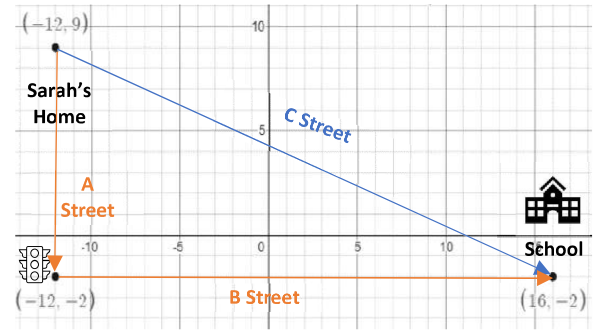
Expectations		Evidence of Student Learning (not all inclusive; see Grade Level Overview for more details)		
8.FGR.6.1	Show that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, visually fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line of best fit.	***Strategies and Methods*** ● Students should discover the line of best fit as the one that comes closest to most of the data points.	***Terminology*** ● The line of best fit shows the linear relationship between two variables in a data set.	***Example*** ● Given a set of data points, a student creates a scatter plot (see below), approximates a line of best fit, and writes the equation for the approximated line. 

8.FGR.6.2	Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercepts.	***Strategies and Methods*** • Students should solve practical, linear problems involving situations using bivariate quantitative data.	***Terminology*** • A linear model shows the relationship between two variables in a data set, such as lines of best fit.
8.FGR.6.3	Explain the meaning of the predicted slope (rate of change) and the predicted intercept (constant term) of a linear model in the context of the data.	***Terminology*** • It is important to indicate 'predicted' to indicate this is a *probabilistic* interpretation in context, and not *deterministic*.	***Example*** • In a linear model for a biology experiment, interpret a slope of 1.5 cm/hr as meaning that an additional hour of sunlight each day is associated with an additional 1.5 cm in mature plant height.
8.FGR.6.4	Use appropriate graphical displays from data distributions involving lines of best fit to draw informal inferences and answer the statistical investigative question posed in an unbiased statistical study.	***Fundamentals*** • Students should be given opportunities to analyze the data distribution displayed graphically to answer the statistical investigative question generated from a realistic situation.	

8.FGR.7: Justify and use various strategies to solve systems of linear equations to model and explain realistic phenomena.			
Expectations		**Evidence of Student Learning** **(not all inclusive; see Grade Level Overview for more details)**	
8.FGR.7.1	Interpret and solve relevant mathematical problems leading to two linear equations in two variables.	***Strategies and Methods*** • Students should have a variety of opportunities to explore problems using technology and tools in order to strengthen their conceptual understanding of systems of linear equations as they visually analyze what happens when the variables are manipulated in the problem.	***Examples*** • A trampoline park that you frequently go to is \$9 per visit. You have the option to purchase a monthly membership for \$30 and then pay \$4 for each visit. Explain whether you will buy the membership, and why. Option A: y = \$9x Option B: y = \$30 + \$4x • Anya is traveling from out of town. This is the only time she will visit this trampoline park. Which option should she choose? • Jin plans on going to the trampoline park seven times this month. Which option should he choose? What does the point of intersection of the graphs represent?
8.FGR.7.2	Show and explain that solutions to a system of two linear equations in two variables correspond to points of intersection of their graphs, because the points of	***Strategies and Methods*** • Students should be provided with opportunities to explore systems of equations represented on interactive graphs to analyze and interpret the solutions to the systems. • Students should be able to analyze and explain solutions to systems of equations presented numerically, algebraically, and graphically.	

	intersection satisfy both equations simultaneously.		
8.FGR.7.3	Approximate solutions of two linear equations in two variables by graphing the equations and solving simple cases by inspection.	***Strategies and Methods*** ● Students should be provided with opportunities to explore systems of equations represented on interactive graphs to analyze and interpret the solutions to the systems. ● Students should have opportunities to analyze and explore problems using technology and tools to strengthen their conceptual understanding of systems of linear equations.	***Example*** ● A student can graph two linear equations that represent a culturally relevant problem using digital graphing tools (i.e., Desmos) and visually make sense of the graphed lines based on a given context. A student can provide a verbal or written explanation of their reasoning.
8.FGR.7.4	Analyze and solve systems of two linear equations in two variables algebraically to find exact solutions.	***Strategies and Methods*** ● Students should be able to analyze and solve pairs of simultaneous linear equations (systems of linear equations) within realistic situations and an expressed phenomenon. ● Students should validate their graphical approximations using algebraic strategies. ● Students should use substitution and elimination to solve systems of linear equations.	***Example*** ● Given coordinates for two pairs of points, a student can determine whether the line through the first pair of points intersects the line through the second pair.
8.FGR.7.5	Create and compare the equations of two lines that are either parallel to each other, perpendicular to each other, or neither parallel nor perpendicular.	***Strategies and Methods*** ● Students should have the opportunity to explore visual graphs of equations that are parallel, perpendicular or neither parallel nor perpendicular to develop a deep, conceptual understanding. ● As students are comparing parallelism and perpendicularity of lines, they should see the connection as a system of equations. ● Students should be able to explain if systems are consistent or inconsistent.	***Example*** ● A student can recognize that there is no solution to the system of equations formed by $3x + 2y = 5$ and $3x + 2y = 6$ because the lines are parallel and $3x + 2y$ cannot simultaneously be 5 and 6.

GEOMETRIC & SPATIAL REASONING *– Pythagorean theorem and volume of triangles, rectangles, cones, cylinders, and spheres*				
8.GSR.8: Solve geometric problems involving the Pythagorean Theorem and the volume of geometric figures to explain real phenomena.				
Expectations		**Evidence of Student Learning** (not all inclusive; see Grade Level Overview for more details)		
8.GSR.8.1	Explain a proof of the Pythagorean Theorem and its converse using visual models.	***Age/Developmentally Appropriate*** • Students are not limited to a particular proof for the Pythagorean Theorem or its converse.	***Strategies and Methods*** • Geometric and spatial reasoning should be used when explaining the Pythagorean Theorem.	***Example*** 
8.GSR.8.2	Apply the Pythagorean Theorem to determine unknown side lengths in right triangles within authentic, mathematical problems in two and three dimensions.	***Age/Developmentally Appropriate*** • Triangle dimensions may be rational or irrational numbers.	***Strategies and Methods*** • Geometric and spatial reasoning should be used to solve problems involving the Pythagorean theorem. • Models and drawings may be useful as students solve contextual problems in two- and three-dimensions.	***Example***  How tall is the Great Pyramid of Giza?
8.GSR.8.3	Apply the Pythagorean Theorem to find the distance between two points in a coordinate system in practical, mathematical problems.	***Age/Developmentally Appropriate*** • Students should apply their understanding of the Pythagorean Theorem to find the distance. Use of the distance formula is not an expectation for this grade level.	***Strategies and Methods*** • Students should be provided opportunities to solve problems using a variety of strategies.	***Example*** • There are two paths that Sarah can take when walking to school. One path is to take is to take A Street from home to the traffic light and then walk on B street from the traffic light to the school, and the other way is for her to take C street directly to the school. How much shorter is the direct path along C Street?

				 To answer this question, students may use what they learned in 6th grade to find the distance between (-12, 9) and (-12, -2) representing A street and the distance between (-12, -2) and (16, -2) representing B street. Then, students could use those two distances to find the sum of the distances for the first path. Then, students can apply the Pythagorean theorem to determine the distance between the final two points, (-12, 9) and (16, -2) to determine the answer to the question.
8.GSR.8.4	Apply the formulas for the volume of cones, cylinders, and spheres and use them to solve in relevant problems.	***Age/Developmentally Appropriate*** ● This learning objective is limited to right circular cones, right cylinders, and spheres.	***Strategies and Methods*** ● Given the volume, solve for an unknown dimension of the figure. Students will need to be able to express the answer in terms of pi and as a decimal approximation. ● Students should be able to use their knowledge of cube roots to solve for unknown dimensions of geometric figures.	***Relevance and Application*** ● Students should be given opportunities to find missing dimensions of a right circular cone (e.g., slant height, radius, etc.). ● Students should be able to make connections between the Pythagorean Theorem and solving relevant problems related to volume of cones.

7th Grade: Create statistical investigative questions that can be answered using quantitative data, collect data through **random sampling** to make **inferences about population distributions** using **data distributions**, and interpret data to answer statistical investigative questions.

Ask	Collect	Analyze	Interpret
Create a statistical investigative question that can be answered by gathering data from real situations and determine strategies for gathering data to answer the statistical investigative question.	**Use statistical reasoning and methods to predict characteristics of a population by examining the characteristics of a representative sample. Recognize the potential limitations and scope of the sample to the population.** **Analyze sampling methods and conclude that random sampling produces and supports valid inferences.**	**Use data from repeated random samples to evaluate how much a sample mean is expected to vary from a population mean. Simulate multiple samples of the same size.**	**Use appropriate graphical displays and numerical summaries from data distributions with categorical or quantitative (numerical) variables to draw informal inferences about two samples or populations.**

Instructional Supports

- Students should have opportunities to create and answer statistical investigative questions about a population by collecting data from a representative sample, using random sampling techniques to collect the data.
- Students should have opportunities to critique examples of sampling techniques. Students should conclude when conditions of sampling methods may be biased, random, and not representative of the population. Students should use sample data collected to draw inferences.
- Students should use side by side bar graphs or segmented bar graphs to compare categorical data distributions of samples from two populations. Students should compare data of two samples or populations displayed in box plots and dot plots to make inferences.
- Students should be able to draw inferences using measures of central tendency (mean, median, mode) and/or variability (range, mean absolute deviation and interquartile range) from random samples. Conclusions should be made related to a population, using a random sample, by describing a distribution using measures of central tendency (mean, median, mode) and/or variability (range, mean absolute deviation, and interquartile range).

8th Grade: Create statistical investigative questions that can be answered using quantitative data. Collect, analyze, and interpret patterns of bivariate data and interpret linear models to answer statistical questions and solve real problems.

Ask	Collect	Analyze	Interpret
Create a statistical investigative question that can be answered by gathering data from real situations and determine strategies for gathering data to answer the statistical investigative question.	**Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercepts.**	**Construct and interpret scatter plots for bivariate quantitative data to investigate patterns of association between two quantities.** **Explain the meaning of the predicted slope (rate of change) and the predicted intercept (constant term) of a linear model in the context of the data.**	**Show that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, visually fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line of best fit.** **Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercepts.** **Use appropriate graphical displays from data distributions involving lines of best fit to draw informal inferences and answer the statistical investigative question posed in an unbiased statistical study.**

Instructional Supports

- Students should be able to use statistical reasoning to describe patterns of association, such as clustering, outliers, positive or negative association, linear association, and nonlinear association through the analysis of data presented in multiple ways.
- Students should be given opportunities to analyze the data distribution displayed graphically to answer the statistical investigative question generated from a real situation.
- Students should solve practical, linear problems involving situations using bivariate quantitative data. A linear model shows the relationship between two variables in a data set, such as lines of best fit. Students should discover the line of best fit as the one that comes closest to most of the data points and shows the linear relationship between two variables in a data set.
- It is important to indicate 'predicted' slope to indicate this is a probabilistic interpretation in context, and not deterministic.

COMPUTATIONAL STRATEGIES FOR WHOLE NUMBERS

Mathematics Place-Value Strategies and US Traditional Algorithms

Specific mathematics strategies for teaching and learning are not mandated by the Georgia Department of Education or assessed on state or federally mandated tests. Students may solve problems in different ways and have the flexibility to choose a mathematical strategy that allows them to make sense of and strategically solve problems using efficient methods that are most comfortable for and makes sense to them. It is critical that teachers and parents remain partners to help each child grow to become a mathematically literate citizen. [These standards preserve and affirm local control and flexibility.]

In mathematics, the emphasis is on the reasoning and thinking about the quantities within mathematical contexts. Algorithms, tape diagrams (bar models), and number line representations are a few examples of ways that students communicate their strategic thinking in a written form.

Addition Example: 1573 + 796

US Traditional Algorithm:

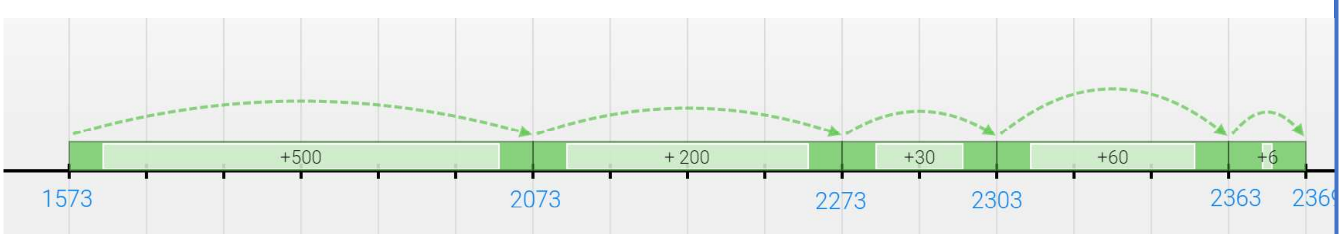
$$\begin{array}{ccccc} & \scriptstyle 1 & \scriptstyle 1 & & \\ & 1 & 5 & 7 & 3 \\ + & & 7 & 9 & 6 \\ \hline & 2 & 3 & 6 & 9 \end{array}$$

Description:
As students make sense of and use addition strategies and algorithms, it is important for them to be given the flexibility to use a part-whole strategy such as place value partitioning, adding on in parts, estimation and compensation, and friendly numbers to communicate their thinking using a written recording of that strategy that is most comfortable for and makes sense to them. Students should be able to demonstrate a deep understanding of the relationship between the quantities presented in the mathematics number sentence and to attend to precision in their explanations. Flexibility in thinking is key!

Place Value Algorithm:

$$\begin{array}{ccccc} & 1 & 5 & 7 & 3 \\ + & & 7 & 9 & 6 \\ \hline & & & & 9 \\ + & & 1 & 6 & 0 \\ + & 1 & 2 & 0 & 0 \\ + & 1 & 0 & 0 & 0 \\ \hline & 2 & 3 & 6 & 9 \end{array}$$

Number Line Representation:



It is important to note that the examples of strategies provided in the tables are not all inclusive. Students may solve problems in different ways and have the flexibility to choose a mathematical strategy that allows them to make sense of and strategically solve problems using efficient methods that are most comfortable for and makes sense to them.

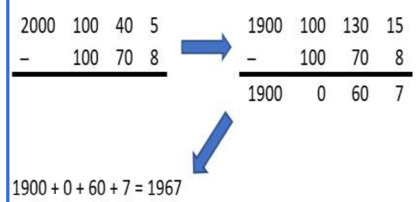
Subtraction Example: 2145 - 178

US Traditional Algorithm:

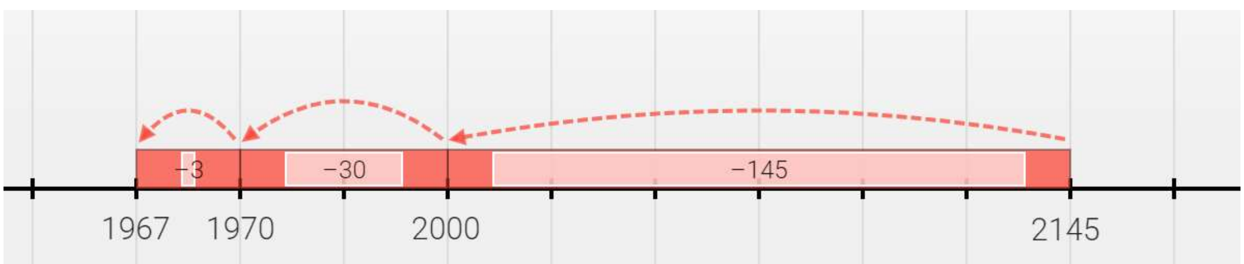
$$
\begin{array}{rrrr}
 & \overset{0}{\cancel{1}} & \overset{13}{\cancel{4}} & \overset{15}{\cancel{5}} \\[-2pt]
2 & & & \\
- & 1 & 7 & 8 \\
\hline
1 & 9 & 6 & 7
\end{array}
$$

Description:
As students make sense of and use subtraction strategies and algorithms, it is important for them to be given the flexibility to use a part-whole strategy such as place value partitioning, adding up, counting back in chunks, and same difference and communicate their thinking using a written recording of that strategy that is most comfortable for and makes sense to them. Students should be able to demonstrate a deep understanding of the relationship between the quantities presented in the mathematics number sentence and to attend to precision in their explanations. Flexibility in thinking is key!

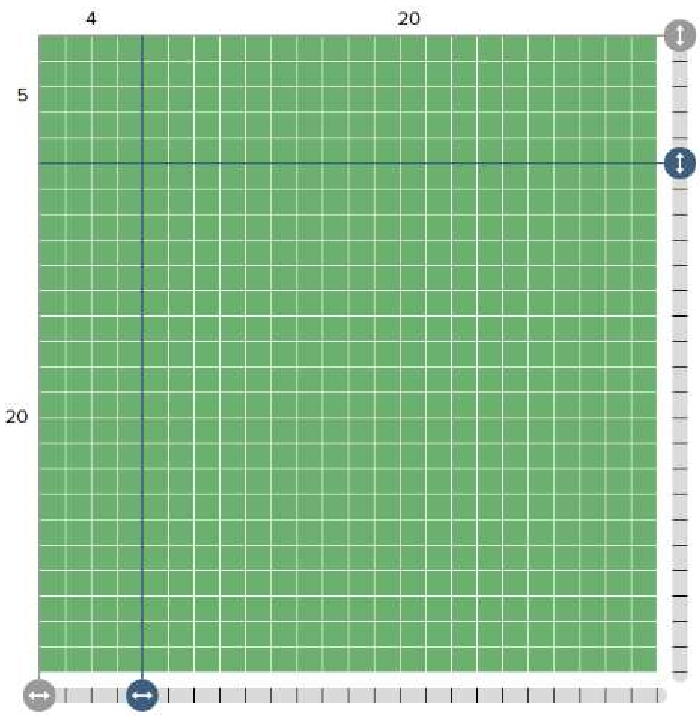
Place Value Algorithm:



Number Line Representation:



It is important to note that the examples of strategies provided in the tables are not all inclusive. Students may solve problems in different ways and have the flexibility to choose a mathematical strategy that allows them to make sense of and strategically solve problems using efficient methods that are most comfortable for and makes sense to them.

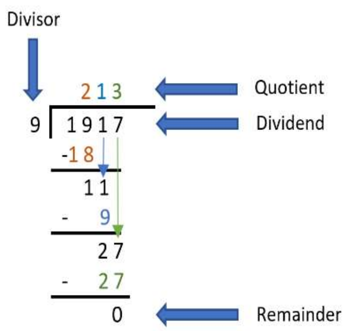
<table>
<tr><th colspan="3">Multiplication Example: 25 x 24</th></tr>
<tr>
<td>US Traditional Algorithm:
$$\begin{array}{rr} & {}^{1}{}_{2} \\ & 25 \\ \times & 24 \\ \hline & 100 \\ + & 500 \\ \hline & 600 \end{array}$$</td>
<td>Description:
As students make sense of and use multiplication strategies and algorithms, it is important for them to demonstrate a deep understanding of the relationship between the quantities presented in the mathematics number sentence and to attend to precision in their explanations. Students are encouraged to use strategies such as partial products, friendly numbers, and a combination of known facts to determine solutions to new problems. It is also important for students to maintain the ability to choose which part-whole strategy is best to communicate their mathematical thinking. Flexibility in thinking is key!</td>
<td>Place Value Algorithm:
$$\begin{array}{rrl} & 25 & \\ \times & 24 & \\ \hline & 400 & (20 \times 20) \\ + & 100 & (20 \times 5) \\ + & 80 & (4 \times 20) \\ + & 20 & (4 \times 5) \\ \hline & 600 & \end{array}$$</td>
</tr>
<tr><td colspan="3">Area Representation (Partial Products):


$(5 \times 4) + (5 \times 20) + (20 \times 4) + (20 \times 20) = (25 \times 24)$</td></tr>
</table>

It is important to note that the examples of strategies provided in the tables are not all inclusive. Students may solve problems in different ways and have the flexibility to choose a mathematical strategy that allows them to make sense of and strategically solve problems using efficient methods that are most comfortable for and makes sense to them.

Division Example: 1917 ÷ 9

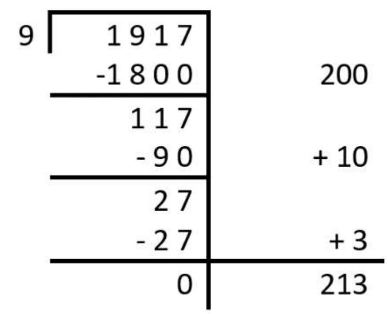
US Traditional Algorithm:



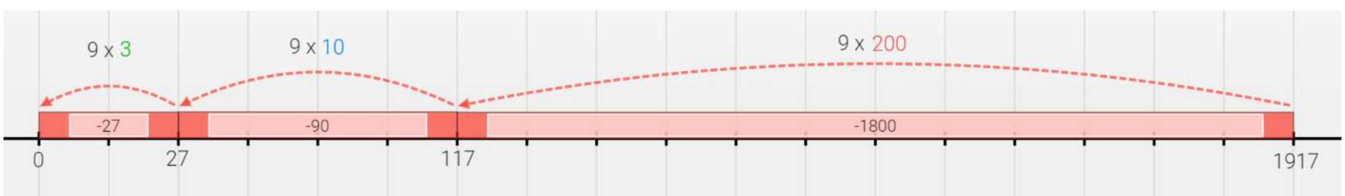
Description:

As students make sense of and use division strategies and algorithms, it is important for them to demonstrate a deep understanding of the relationship between the quantities. Students are encouraged to use strategies such as partial quotients, friendly numbers, and repeated subtraction to determine solutions to new problems. It is also important for students to maintain the ability to choose which strategy is best to communicate their mathematical thinking. Flexibility in thinking is key!

Place Value Algorithm:



Number Line Representation:



200 + 10 + 3 = 213

It is important to note that the examples of strategies provided in the tables are not all inclusive. Students may solve problems in different ways and have the flexibility to choose a mathematical strategy that allows them to make sense of and strategically solve problems using efficient methods that are most comfortable for and makes sense to them.

GEORGIA'S K-12
MATHEMATICS STANDARDS
2021

Algebra:

Concepts & Connections

(HS Course 1)

MATHEMATICS
KEY COMPETENCIES &
COURSE STANDARDS

WITH
LEARNING OBJECTIVES
IN PROGRESSION ORDER

GEORGIA’S K-12 MATHEMATICS STANDARDS 2021

Governor Kemp and Superintendent Woods are committed to the best set of academic standards for Georgia’s students – laying a strong foundation of the fundamentals, ensuring age- and developmentally appropriate concepts and content, providing instructional supports to set our teachers up for success, protecting and affirming local control and flexibility regarding the use of mathematical strategies and methods, and preparing students for life. These Georgia-owned and Georgia-grown standards leverage the insight, expertise, experience, and efforts of thousands of Georgians to deliver the very best educational experience for Georgia's 1.7 million students.

In August 2019, Governor Brian Kemp and State School Superintendent Richard Woods announced the review and revision of Georgia's K-12 mathematics standards. Georgians have been engaged throughout the standards review and revision process through public surveys and working groups. In addition to educator working groups, surveys, and the Academic Review Committee, Governor Kemp announced a new way for Georgians to provide input on the standards: the Citizens Review Committee, a group composed of students, parents, business and community leaders, and concerned citizens from across the state. Together, these efforts were undertaken to ensure Georgians will have buy-in and faith in the process and product.

The Citizens Review Committee provided a charge and recommendations to the working groups of educators who came together to craft the standards, ensuring the result would be usable and friendly for parents and students in addition to educators. More than 14,000 Georgians participated in the state's public survey from July through September 2019, providing additional feedback for educators to review. The process of writing the standards involved more than 200 mathematics educators -- from beginning to veteran teachers, representing rural, suburban, and metro areas of our state.

Grade-level teams of mathematics teachers engaged in deep discussions; analyzed stakeholder feedback; reviewed every single standard, concept, and skill; and provided draft recommendations. To support fellow mathematics teachers, they also developed learning progressions to show when key concepts were introduced and how they progressed across grade levels, provided examples, and defined age/developmentally appropriate expectations.

These teachers reinforced that strategies and methods for solving mathematical problems are classroom decisions -- not state decisions -- and should be made with the best interest of the individual child in mind. These recommended revisions have been shared with the Academic Review Committee, which is composed of postsecondary partners, age/development experts, and business leaders, as well as the Citizens Review Committee, for final input and feedback.

Based on the recommendation of Superintendent Woods, the State Board of Education will vote to post the draft K-12 mathematics standards for public comment. Following public comment, the standards will be recommended for adoption, followed by a year of teacher training and professional learning prior to implementation.

Algebra: Concepts & Connections

Overview

This document contains a draft of Georgia's 2021 K-12 Mathematics Standards for the High School Algebra: Concepts and Connections Course, which is the first course in the high school course sequence.

The standards are organized into big ideas, course competencies/standards, and learning objectives/expectations. The grade level key competencies represent the standard expectation of learning for students in each grade level. The competencies/standards are each followed by more detailed learning objectives that further explain the expectations for learning in the specific grade levels.

New instructional supports are included, such as clarification of language and expectations, as well as detailed examples. These have been provided for teaching professionals and stakeholders through the Evidence of Student Learning Column that accompanies each learning objective.

Course Description:

This course is designed as the first course in a three-course series. Students will apply their algebraic and geometric reasoning skills to make sense of problems involving algebra, geometry, bivariate data, and statistics. This course focuses on algebraic, quantitative, geometric, graphical, and statistical reasoning. In this course, students will continue to enhance their algebraic reasoning skills when analyzing and applying a deep understanding of linear functions, sums and products of rational and irrational numbers, systems of linear inequalities, distance, midpoint, slope, area, perimeter, nonlinear equations and functions, quadratic expressions, equations and functions, exponential expressions, equations, and functions, and statistical reasoning.

High school course content standards are listed by big ideas including Data and Statistical Reasoning, Probabilistic Reasoning, Functional and Graphical Reasoning, Patterning and Algebraic Reasoning, and Geometry Patterning and Spatial Reasoning.

Prerequisite:

This course is designed for students who have successfully completed *Kindergarten through 8th grade mathematics.*

Georgia's K-12 Mathematics Standards - 2021
Mathematics Big Ideas and Learning Progressions, High School

Mathematics Big Ideas, HS

HIGH SCHOOL
MATHEMATICAL PRACTICES (MP)
MATHEMATICAL MODELING (MM)
NUMERICAL REASONING (NR)
PATTERNING & ALGEBRAIC REASONING (PAR)
FUNCTIONAL & GRAPHICAL REASONING (FGR)
GEOMETRIC & SPATIAL REASONING (GSR)
DATA & STATISTICAL REASONING (DSR)
PROBABILISTIC REASONING (PR)

The 8 Mathematical Practices and the Mathematical Modeling Framework are essential to the implementation of the content standards presented in this course. More details related to these concepts can be found in the links below and in the first two standards presented in this course:

Mathematical Practices

Mathematical Modeling Framework

Algebra: Concepts & Connections

The eleven course standards listed below are the key content competencies students will be expected to master in this course. Additional clarity and details are provided through the classroom-level learning objectives and evidence of student learning details for each course standard found on subsequent pages of this document.

COURSE STANDARDS
A.MP: Display perseverance and patience in problem-solving. Demonstrate skills and strategies needed to succeed in mathematics, including critical thinking, reasoning, and effective collaboration and expression. Seek help and apply feedback. Set and monitor goals.
A.MM.1: Apply mathematics to real-life situations; model real-life phenomena using mathematics.
A.FGR.2: Construct and interpret arithmetic sequences as functions, algebraically and graphically, to model and explain real-life phenomena. Use formal notation to represent linear functions and the key characteristics of graphs of linear functions, and informally compare linear and non-linear functions using parent graphs.
A.GSR.3: Solve problems involving distance, midpoint, slope, area, and perimeter to model and explain real-life phenomena.
A.PAR.4: Create, analyze, and solve linear inequalities in two variables and systems of linear inequalities to model real-life phenomena.
A.NR.5: Investigate rational and irrational numbers and rewrite expressions involving square roots and cube roots.
A.PAR.6: Build quadratic expressions and equations to represent and model real-life phenomena; solve quadratic equations in mathematically applicable situations.
A.FGR.7: Construct and interpret quadratic functions from data points to model and explain real-life phenomena; describe key characteristics of the graph of a quadratic function to explain a mathematically applicable situation for which the graph serves as a model.
A.PAR.8: Create and analyze exponential expressions and equations to represent and model real-life phenomena; solve exponential equations in mathematically applicable situations.
A.FGR.9: Construct and analyze the graph of an exponential function to explain a mathematically applicable situation for which the graph serves as a model; compare exponential with linear and quadratic functions.
A.DSR.10: Collect, analyze, and interpret univariate quantitative data to answer statistical investigative questions that compare groups to solve real-life problems; Represent bivariate data on a scatter plot and fit a function to the data to answer statistical questions and solve real-life problems.

Algebra: Concepts & Connections

MATHEMATICAL MODELING			
A.MM.1: Apply mathematics to real-life situations; model real-life phenomena using mathematics.			
Expectations		**Evidence of Student Learning** **(not all inclusive; see Course Overview for more details)**	
A.MM.1.1	Explain applicable, mathematical problems using a mathematical model.	***Fundamentals*** • Students should be provided with opportunities to learn mathematics in the framework of real-life problems. • Mathematically applicable problems are those presented in which the given framework makes sense, realistically and mathematically, and allows for students to make decisions about how to solve the problem (model with mathematics).	
A.MM.1.2	Create mathematical models to explain phenomena that exist in the natural sciences, social sciences, liberal arts, fine and performing arts, and/or humanities domains.	***Fundamentals*** • Students should be able to use the content learned in this course to create a mathematical model to explain real-life phenomena.	
A.MM.1.3	Use units of measure (linear, area, capacity, rates, and time) as a way to make sense of conceptual problems; identify, use, and record appropriate units of measure within the given framework, within data displays, and on graphs; convert units and rates using proportional reasoning given a conversion factor; use units within multi-step problems and formulas; interpret units of input and resulting units of output.	***Strategies and Methods*** • Dimensional analysis may be used when converting units and rates.	***Examples*** • Units of measure may include linear, area, capacity, rates, and time.
A.MM.1.4	Use various mathematical representations and structures with this information to represent and solve real-life problems.	***Strategies and Methods*** • Students should be able to fluently navigate between mathematical representations that are presented numerically, algebraically, and graphically. • For graphical representations, students should be given opportunities to analyze graphs using interactive graphing technologies.	
A.MM.1.5	Define appropriate quantities for the purpose of descriptive modeling.	***Fundamentals*** • Given a situation, framework, or problem, students should be able to determine, identify, and use appropriate quantities for representing the situation.	

FUNCTIONAL & GRAPHICAL REASONING – function notation, modeling linear functions, linear vs. nonlinear comparisons		
A.FGR.2: Construct and interpret arithmetic sequences as functions, algebraically and graphically, to model and explain real-life phenomena. Use formal notation to represent linear functions and the key characteristics of graphs of linear functions, and informally compare linear and non-linear functions using parent graphs.		
Expectations		**Evidence of Student Learning** **(not all inclusive; see Course Overview for more details)**
A.FGR.2.1	Use mathematically applicable situations algebraically and graphically to build and interpret arithmetic sequences as functions whose domain is a subset of the integers.	***Fundamentals*** • Students should be able to: ○ make connections between linear functions and arithmetic sequences presented in mathematically applicable-situations. ○ build and interpret arithmetic sequences as functions presented graphically and algebraically. ○ convert arithmetic sequences from explicit to recursive form and vice versa. ○ define sequences recursively and explicitly. ***Example*** • By graphing or calculating terms, students should be able to show how the arithmetic sequence in recursive form $a_1=7$, $a_n=a_{n-1}+2$; the arithmetic sequence in explicit form $a_n = 2(n-1) + 7$; and the function $f(x) = 2x + 5$ (when x is a natural number) all define the same sequence.
A.FGR.2.2	Construct and interpret the graph of a linear function that models real-life phenomena and represent key characteristics of the graph using formal notation.	***Strategies and Methods*** • Students should be able to use graphs created by hand and with technology, verbal descriptions, tables, and function notation when analyzing linear functions that represent real-life phenomena. • Students should be given opportunities to use interactive graphing technologies to explore and analyze key characteristics of linear functions, including domain, range, intercepts, intervals where the function is increasing or decreasing, positive or negative, maximums and minimums over a specified interval, and end behavior. ***Fundamentals*** • Students should be able to express characteristics in interval and set notation with linear functions. • Students should be able to interpret the key characteristics of the graph in a situation.
A.FGR.2.3	Relate the domain and range of a linear function to its graph and, where applicable, to the quantitative relationship it describes. Use formal interval and set notation to describe the domain and range of linear functions.	***Examples*** • If the function h(n) gives the number of hours it takes a person to assemble n engines in a factory, then the set of positive integers would be an appropriate domain for the function. • Use symbolic notation to represent the domain and range of a linear function, considering the specific context. ○ $(-\infty,\infty)$ ○ $[3, \infty)$ ○ D: $\{x \mid x \in \mathbb{R}\}$ ○ D: $\{x \mid x > 0\}$ ○ D: $\{x \mid x = 1,2,3,4,5,\ldots\}$ ○ R: $\{y \mid y = 10,20,30,\ldots\}$
A.FGR.2.4	Use function notation to build and evaluate linear functions for inputs in their domains and interpret statements that use function	***Fundamentals*** • Student should develop a deep understanding of function notation to build, evaluate, and interpret linear functions; this understanding will be applied to other functions studied hereafter.

	notation in terms of a mathematical framework.	• Students should be able to interpret the domain when given a function expressed numerically, algebraically, and graphically.	
A.FGR.2.5	Analyze the difference between linear functions and nonlinear functions by informally analyzing the graphs of various parent functions (linear, quadratic, exponential, absolute value, square root, and cube root parent curves).	***Fundamentals*** • Students should explore the parent function graphs to compare linear and nonlinear relationships (including a visual analysis of end behavior, increasing and decreasing, domain and range, intercepts, and general curvature). • Learning all the characteristics of these nonlinear functions is not an expectation for this learning objective. • Students should be able to identify parent functions by name (i.e., linear, quadratic, etc.). • Students should have opportunities to explore the various graphs using technology.	***Strategies and Methods*** • Students should be able to informally analyze the curvature of several parent functions to highlight the characteristics of linear functions in comparison to several nonlinear functions. • This is an introduction to functions they will explore in future units and courses. • Student should be provided opportunities to utilize graphing calculators and interactive graphing technologies to explore this concept.

GEOMETRIC & SPATIAL REASONING – *distance, midpoint, slope, area, and perimeter*			
A.GSR.3: Solve problems involving distance, midpoint, slope, area, and perimeter to model and explain real-life phenomena.			
Expectations		**Evidence of Student Learning** **(not all inclusive; see Course Overview for more details)**	
A.GSR.3.1	Solve real-life problems involving slope, parallel lines, perpendicular lines, area, and perimeter.	***Fundamentals*** • Students should apply their understanding of linear relationships to solve real-life, application problems related to slope, parallel lines, perpendicular lines, area, and perimeter. • Students should be able to calculate the area and perimeter of special parallelograms and triangles with simple, unknown side lengths.	
A. GSR.3.2	Apply the distance formula, midpoint formula, and slope of line segments to solve real-world problems.	***Fundamentals*** • Students should be able to apply their understanding of slope and use the distance and midpoint formulas to solve real-world problems. • In a real-life application, using a figure in the coordinate plane, students should be able to find a location using distance or midpoint.	***Example*** • Find the distance of a line segment plotted on the coordinate plane.

PATTERNING & ALGEBRAIC REASONING – *linear inequalities and systems of linear inequalities*			
A.PAR.4: Create, analyze, and solve linear inequalities in two variables and systems of linear inequalities to model real-life phenomena.			
Expectations		**Evidence of Student Learning** (not all inclusive; see Course Overview for more details)	
A.PAR.4.1	Create and solve linear inequalities in two variables to represent relationships between quantities including mathematically applicable situations; graph inequalities on coordinate axes with labels and scales.	***Fundamentals*** • Students should be given the opportunity to explore the difference between solid lines and dashed lines through exploration on an interactive graph. • Students should have had opportunities to create and solve linear equations and inequalities throughout middle school mathematics. • Students should recognize that the graph of a linear inequality in two variables is a half-plane.	***Strategies and Methods*** • When necessary, students should be able to rewrite the inequality in various forms, such as slope-intercept form, for graphing. • Students should be given opportunities to solve linear inequalities graphically and algebraically. These linear inequalities should represent realistic, real-life phenomena.
A.PAR.4.2	Represent constraints of linear inequalities and interpret data points as possible or not possible.	***Terminology*** • Possible data points are solutions to the inequality or inequalities; data points that are not possible are non-solutions to the inequality or inequalities.	
A.PAR.4.3	Solve systems of linear inequalities by graphing, including systems representing a mathematically applicable situation.	***Fundamentals*** • Ensure constraints are represented. • Students in Grade 8 mathematics modeled with and solved systems of linear equations to solve real-life problems.	***Strategies and Methods*** • Students should be provided opportunities to use technology tools to solve systems of linear inequalities graphically.

NUMERICAL REASONING - *rational and irrational numbers, square roots and cube roots*			
A.NR.5: Investigate rational and irrational numbers and rewrite expressions involving square roots and cube roots.			
Expectations		**Evidence of Student Learning** (not all inclusive; see Course Overview for more details)	
A.NR.5.1	Rewrite algebraic and numeric expressions involving radicals.	***Relevance and Application*** • Students should be able to use the operations of addition, subtraction, and multiplication, with radicals within expressions limited to square roots and cube roots.	
A.NR.5.2	Using numerical reasoning, show and explain that the sum or product of rational numbers is rational, the sum of a rational number and an irrational number is irrational, and the product of a nonzero rational number and an irrational number is irrational.	**Fundamentals** • The tasks selected should aid students with their development of a conceptual understanding of the sums and products of rational and irrational numbers through exploration and investigation. • Students should be able to judge the reasonableness of an answer based on their understanding of rational and irrational numbers.	**Examples** • Students should know that adding two irrational numbers, such as $3\sqrt{5}$ and $\sqrt{7}$, may result in an irrational number. • The side length of a square is $\sqrt{8}$. Is the perimeter a rational or irrational number?

<table>
<tr><td colspan="6">PATTERNING & ALGEBRAIC REASONING – quadratic expressions & equations</td></tr>
<tr><td colspan="6">A.PAR.6: Build quadratic expressions and equations to represent and model real-life phenomena; solve quadratic equations in mathematically applicable situations.</td></tr>
<tr><th colspan="2">Expectations</th><th colspan="4">Evidence of Student Learning
(not all inclusive; see Course Overview for more details)</th></tr>
<tr><td>A.PAR.6.1</td><td>Interpret quadratic expressions and parts of a quadratic expression that represent a quantity in terms of its context.</td><td colspan="4">Fundamentals
• Students should be able to interpret parts of an expression, such as terms, factors, leading coefficient, coefficients, constant and degree in context.
• Given mathematically applicable situations which utilize formulas or expressions with multiple terms and/or factors, students should be able to interpret the meaning of given individual terms or factors.</td></tr>
<tr><td>A.PAR.6.2</td><td>Fluently choose and produce an equivalent form of a quadratic expression to reveal and explain properties of the quantity represented by the expression.</td><td colspan="2">Fundamentals
• Students should be able to multiply variable expressions involving the product of a monomial and a binomial and the product of two binomials to produce a quadratic expression.
• Polynomial operations are included with this objective. Polynomial sums, differences, and products should not exceed a maximum degree of 2.</td><td colspan="2">Strategies and Methods
• Students should be able to move fluently (flexibly, accurately, efficiently) between different forms of a quadratic expression (standard, vertex, and factored forms).
• Students should be able to use the structure of a quadratic expression to rewrite it in different equivalent forms.</td></tr>
<tr><td>A.PAR.6.3</td><td>Create and solve quadratic equations in one variable and explain the solution in the framework of applicable phenomena.</td><td>Fundamentals
• Students should be able to multiply variable expressions involving the product of a monomial and a binomial and the product of two binomials to solve a quadratic equation.</td><td colspan="2">Strategies and Methods
• Students should be able to solve quadratic equations fluently (flexibly, accurately, efficiently) by inspection, taking square roots, factoring, completing the square, and applying the quadratic formula, as appropriate to the initial form of the equation.
• Students should be able to fluently transform a quadratic equation in x into an equation of the form $(x – p)^2 = q$ that has the same solutions.
• Students should be able to analyze and explain what the zeros describe in context.</td><td>Relevance and Application
• Limit to real number solutions.</td></tr>
<tr><td>A.PAR.6.4</td><td>Represent constraints by quadratic equations and interpret data points as possible or not possible in a modeling framework.</td><td colspan="4">Terminology
• Possible data points are solutions to the equation(s); data points that are not possible are non-solutions to the equation(s).</td></tr>
</table>

FUNCTIONAL & GRAPHICAL REASONING – quadratic functions		
A.FGR.7: Construct and interpret quadratic functions from data points to model and explain real-life phenomena; describe key characteristics of the graph of a quadratic function to explain a mathematically applicable situation for which the graph serves as a model.		
Expectations		**Evidence of Student Learning** **(not all inclusive; see Course Overview for more details)**
A.FGR.7.1	Use function notation to build and evaluate quadratic functions for inputs in their domains and interpret statements that use function notation in terms of a given framework.	***Fundamentals*** • Students should apply their understanding of function notation from their work with linear functions to build, evaluate, and interpret quadratic functions using function notation. • Students should be able to interpret the domain given a function expressed numerically, algebraically, and graphically.
A.FGR.7.2	Identify the effect on the graph generated by a quadratic function when replacing f(x) with f(x) + k, kf(x), f(kx), and f(x + k) for specific values of k (both positive and negative); find the value of k given the graphs.	***Strategies and Methods*** • Students should be given opportunities to experiment with cases and illustrate an explanation of the effects on the graph using technology.
A.FGR.7.3	Graph and analyze the key characteristics of quadratic functions.	***Strategies and Methods*** • Students should be able to use verbal descriptions, tables, and graphs created using interactive technology tools. ***Fundamentals*** • Students should be able to sketch a graph showing key features including domain, range, and intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; asymptotes; end behavior. • Key characteristics of the quadratic functions should be expressed in interval and set-builder notation using inequalities.
A.FGR.7.4	Relate the domain and range of a quadratic function to its graph and, where applicable, to the quantitative relationship it describes.	***Examples*** • If the function *h(t)* gives the path of a projectile over time, *t*, then the set of non-negative real numbers would be an appropriate domain for the function because time does not include negative values. • A bird is building a nest in a tree 36 feet above the ground. The bird drops a stick from the nest. The function $f(x) = -16x^2 + 36$ describes the height of the stick in feet after *x* seconds. Graph this function. Identify the domain and range of this function. *(A student should be able to determine that the appropriate values for the domain and range of this graph are $0 \le x \le 1.5$ and $0 \le y \le 36$, respectively.)*
A.FGR.7.5	Rewrite a quadratic function representing a mathematically applicable situation to reveal the maximum or minimum value of the function it defines. Explain what the value describes in context.	***Fundamentals*** • Students should be able to interpret the maximum and minimum value of a quadratic function expressed in a variety of ways. ***Strategies and Methods*** • Students should be able to use interactive graphing technologies to make sense of the maximum and minimum values in context. ***Example*** • Consider the path of a football thrown through the air. When does the football reach its maximum height? How high does the football reach?

A.FGR.7.6	Create quadratic functions in two variables to represent relationships between quantities; graph quadratic functions on the coordinate axes with labels and scales.	***Strategies and Methods*** • Students should be able to use interactive graphing technologies to make sense of the visual, graphical model for a quadratic function representing a mathematically applicable situation.
A.FGR.7.7	Estimate, calculate, and interpret the average rate of change of a quadratic function and make comparisons to the average rate of change of linear functions.	***Fundamentals*** • Students should be given opportunities to estimate the rate of change from a graph. • Students should be able to show that linear functions grow by equal differences over equal intervals and recognize situations in which one quantity changes at a constant rate per unit interval relative to another. Students should be able to compare this behavior to that of the average rate of change of quadratic functions. This can be shown by algebraic proof, with a table showing differences, or by calculating average rates of change over equal intervals. ***Strategies and Methods*** • Functions can be presented symbolically, as a graph, or as a table.
A.FGR.7.8	Write a function defined by a quadratic expression in different but equivalent forms to reveal and explain different properties of the function.	***Strategies and Methods*** • Students should be able to move fluently (flexibly, accurately, efficiently) between the factored form, vertex form, and standard form of a quadratic function. ***Fundamentals*** • Students should be able to examine a quadratic function by analyzing the zeros, extreme values, and symmetry of the graph and interpret these properties in context. ***Strategies and Methods*** • Students should be given opportunities to use a variety of strategies and methods to make sense of the properties of quadratic functions: ○ Factoring ○ Completing the square ○ Quadratic formula ○ Graphing ○ Taking square roots ***Example*** • Students should be able to compare quadratic functions in standard, vertex, and intercept forms.
A.FGR.7.9	Compare characteristics of two functions each represented in a different way.	***Fundamentals*** • Functions can be presented numerically in tables, algebraically, graphically, and by verbal descriptions. • Students should be able to: ○ compare a quadratic function to a linear function, or another quadratic function. ○ compare key characteristics of quadratic functions with the key characteristics of linear functions. ○ observe using graphs and tables that a quantity increasing quadratically will eventually exceed a portion of a quantity increasing linearly. ***Examples*** • Given a graph of one quadratic function and an algebraic equation for another, students should be able to determine which has the larger maximum. • Given a graph of one function and an algebraic equation for another, students should be able to determine which has the larger y-intercept.

PATTERNING & ALGEBRAIC REASONING – *exponential expressions and equations*		
A.PAR.8: Create and analyze exponential expressions and equations to represent and model real-life phenomena; solve exponential equations in mathematically applicable situations.		
Expectations		**Evidence of Student Learning** (not all inclusive; see Course Overview for more details)
A.PAR.8.1	Interpret exponential expressions and parts of an exponential expression that represent a quantity in terms of its framework.	***Fundamentals*** • Students should be able to interpret parts of an expression, such as terms, factors, leading coefficient, coefficients, constant and degree in context. • Given mathematically applicable situations which utilize formulas or expressions with multiple terms and/or factors, students should be able to interpret the meaning in context of individual terms or factors.
A.PAR.8.2	Create exponential equations in one variable and use them to solve problems, including mathematically applicable situations.	***Relevance and Application*** • Exponential equations are limited to those containing like bases, or exponential equations that could easily be transferred to like bases with linear operations.
A.PAR.8.3	Create exponential equations in two variables to represent relationships between quantities, including in mathematically applicable situations; graph equations on coordinate axes with labels and scales.	***Example*** • Exponential growth and decay situations are an expectation for this learning objective.
A.PAR.8.4	Represent constraints by exponential equations and interpret data points as possible or not possible in a modeling environment.	***Terminology*** • Possible data points are solutions to the equation(s); data points that are not possible are non-solutions to the equation(s).

FUNCTIONAL & GRAPHICAL REASONING – *exponential functions*		
A.FGR.9: Construct and analyze the graph of an exponential function to explain a mathematically applicable situation for which the graph serves as a model; compare exponential with linear and quadratic functions.		
Expectations		**Evidence of Student Learning** (not all inclusive; see Course Overview for more details)
A.FGR.9.1	Use function notation to build and evaluate exponential functions for inputs in their domains and interpret statements that use function notation in terms of a context.	***Fundamentals*** • Students should apply their understanding of function notation from their work with linear and quadratic functions to build, evaluate, and interpret exponential functions using function notation. • Students should be able to interpret the domain given a function expressed numerically, algebraically, and graphically.
A.FGR.9.2	Graph and analyze the key characteristics of simple exponential functions based on mathematically applicable situations.	***Examples*** • If the function, $h(n)$, gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function. • The function can be presented symbolically, as a graph, or as a table. • Students should be able to estimate the rate of change from a graph.

		• Students should be able to sketch a graph of an exponential function showing key features including domain, range, intercepts, average rate of change, intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; asymptotes; end behavior. • Students should be given opportunities to show that linear functions grow by a constant rate and that exponential functions grow by equal factors over equal intervals. This can be shown by algebraic proof, with a table showing differences, or by calculating average rates of change over equal intervals. • Students should be able to precisely use verbal descriptions, tables, and graphs created by hand and using technology. • Students should be able to create graphs by hand and using graphing technology (i.e., graphing calculator or online interactive graphing technology) • Students should be able to accurately express characteristics in interval notation and set-builder notation using inequalities.	
A.FGR.9.3	Identify the effect on the graph generated by an exponential function when replacing f(x) with f(x) + k, and k f(x), for specific values of k (both positive and negative); find the value of k given the graphs.	***Strategies and Methods*** • Students should be given opportunities to experiment with cases and illustrate an explanation of the effects on the graph using interactive technology.	
A.FGR.9.4	Use mathematically applicable situations algebraically and graphically to build and interpret geometric sequences as functions whose domain is a subset of the integers.	***Fundamentals*** • Sequences can be defined recursively and explicitly. • Connections should be made between exponential functions and geometric sequences. • The focus of this learning objective is on building and interpreting geometric sequences. • Students should be able to covert geometric sequences from explicit form to recursive and vice versa. • Students should have ample opportunities to compare geometric sequences with arithmetic sequences presented in a variety of ways.	***Example*** • By graphing or calculating terms, students should be able to show how the geometric sequence in recursive form $a_1=8$, $a_n=2a_{n-1}$; the geometric sequence in explicit form $s_n = 8(2)^{n-1}$; and the function $f(x) = 4(2)^x$ (when x is a natural number) all define the same sequence.
A.FGR.9.5	Compare characteristics of two functions each represented in a different way.	***Fundamentals*** • Students should be able to present functions algebraically, graphically, and numerically in tables, or by verbal descriptions. • Students should be able to compare an exponential function to a linear function, a quadratic function, or to another exponential function. • Students should be able to compare key characteristics of exponential functions with the key characteristics of linear and quadratic functions. • Students should be able to observe using graphs and tables that a quantity increasing quadratically will eventually exceed a portion of a quantity increasing linearly. • Students should be able to observe using graphs and tables that a quantity increasing exponentially will eventually exceed a portion of a quantity increasing linearly or quadratically.	***Example*** • Given a graph of one function and an algebraic expression for another, determine which has the larger y-intercept.

***DATA & STATISTICAL REASONING** – univariate data and single quantitative variables; bivariate data*

A.DSR.10: Collect, analyze, and interpret univariate quantitative data to answer statistical investigative questions that compare groups to solve real-life problems; Represent bivariate data on a scatter plot and fit a function to the data to answer statistical questions and solve real-life problems.

Expectations		Evidence of Student Learning **(not all inclusive; see Course Overview for more details)**	
A.DSR.10.1	Use statistics appropriate to the shape of the data distribution to compare and represent center (median and mean) and variability (interquartile range, standard deviation) of two or more distributions by hand and using technology.	***Terminology*** • Measures of center include the median and mean. • Measures of spread include the range, interquartile range and standard deviation. • Univariate data involves describing a single variable, such as the age of a student or the height of a student. • Bivariate data involves relationships between two variables, such as comparing the age of a student and their height.	***Fundamentals*** • Students should use the meaning of mean absolute deviation (MAD) learned in sixth grade to interpret the meaning of standard deviation. • Students were first introduced to the concept of MAD as a tool for comparing variability of multiple data sets in sixth grade mathematics. • Students should initially have opportunities to explore standard deviation, by hand, with small data sets, to gain conceptual understanding. • Students should advance to using technology to determine standard deviation to solve problems and answers statistical investigative questions.
A.DSR.10.2	Interpret differences in shape, center, and variability of the distributions based on the investigation, accounting for possible effects of extreme data points (outliers).	***Strategies and Methods*** • Use the 1.5 IQR rule to determine the outliers and analyze their effects on the data set.	***Example*** • Using the 1.5 IQR rule on data set {5,7,8,10,11,12,30}, 30 is determined to be an outlier since it is greater than 19.5, which is the 1.5*IQR +12 (the Q3).
A.DSR.10.3	Represent data on two quantitative variables on a scatter plot and describe how the variables are related.	***Fundamentals*** • Students should be able to describe the direction, strength, and form (linear, non-linear) of the association between two quantitative variables.	
A.DSR.10.4	Interpret the slope (predicted rate of change) and the intercept (constant term) of a linear model based on the-investigation of the data.	***Strategies and Methods*** • Students should be given the opportunity to utilize interactive graphing technologies to model linear data and make sense of the slope (predicted rate of change) visually.	
A.DSR.10.5	Calculate the line of best fit and interpret the correlation coefficient, *r,* of a linear fit using technology. Use *r* to describe the strength of the goodness of fit of the regression. Use the linear function to make predictions and	***Strategies and Methods*** • Students should be given the opportunity to utilize interactive graphing technologies to interpret the correlation coefficient, *r*.	***Fundamentals*** • Students should be able to use the line of best fit and the correlation coefficient, *r*, to make predictions and describe the reasonableness of the prediction in the investigation of a practical, real-life situation.

	assess how reasonable the prediction is in context.		
A.DSR.10.6	Decide which type of function is most appropriate by observing graphed data.	***Fundamentals*** • Students should be able to emphasize linear, quadratic, and exponential models.	
A.DSR.10.7	Distinguish between correlation and causation.	***Application and Relevance*** • It is important for students to discover and understand that strong association does not indicate causation.	

ESSENTIAL INSTRUCTIONAL GUIDANCE

MATHEMATICAL PRACTICES

The Mathematical Practices describe the reasoning behaviors students should develop as they build an understanding of mathematics – the "habits of mind" that help students become mathematical thinkers. There are eight standards, which apply to all grade levels and conceptual categories.

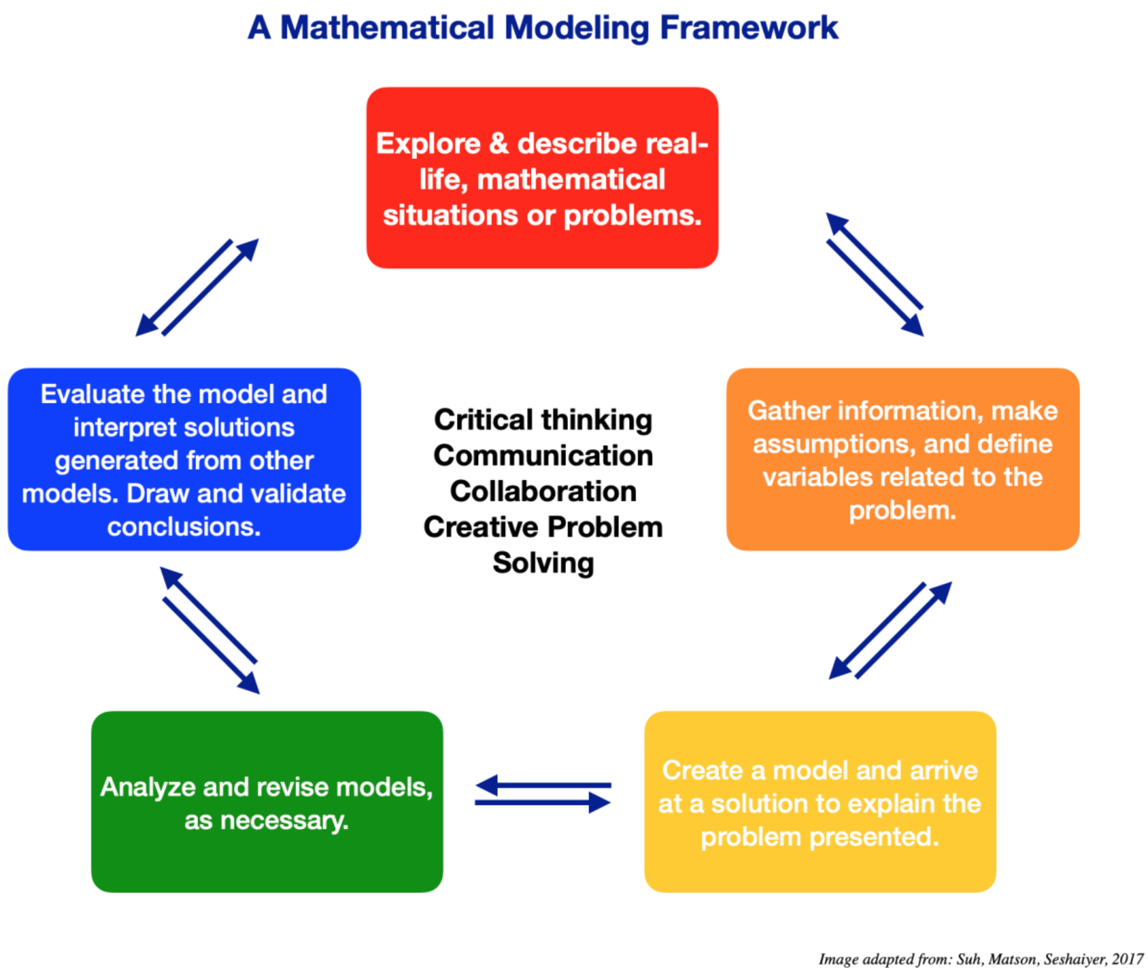
These mathematical practices describe how students should engage with the mathematics content for their grade level. Developing these habits of mind builds students' capacity to become mathematical thinkers. These practices can be applied individually or together in mathematics lessons, and no particular order is required. In well-designed lessons, there are often two or more Standards for Mathematical Practice present.

MATHEMATICAL PRACTICES	
A.MP: Display perseverance and patience in problem-solving. Demonstrate skills and strategies needed to succeed in mathematics, including critical thinking, reasoning, and effective collaboration and expression. Seek help and apply feedback. Set and monitor goals.	
Code	**Expectation**
A.MP.1	Make sense of problems and persevere in solving them.
A.MP.2	Reason abstractly and quantitatively.
A.MP.3	Construct viable arguments and critique the reasoning of others.
A.MP.4	Model with mathematics.
A.MP.5	Use appropriate tools strategically.
A.MP.6	Attend to precision.
A.MP.7	Look for and make use of structure.
A.MP.8	Look for and express regularity in repeated reasoning.

MATHEMATICAL MODELING

Teaching students to model with mathematics is engaging, builds confidence and competence, and gives students the opportunity to collaborate and make sense of the world around them, the main reason for doing mathematics. For these reasons, mathematical modeling should be incorporated at every level of a student's education. This is important not only to develop a deep understanding of mathematics itself, but more importantly to give students the tools they need to make sense of the world around them. Students who engage in mathematical modeling will not only be prepared for their chosen career but will also learn to make informed daily life decisions based on data and the models they create.

The diagram below is a mathematical modeling framework depicting a cycle of how students can engage in mathematical modeling when solving a real-life problem or task.



FRAMEWORK FOR STATISTICAL REASONING

Statistical reasoning is important for learners to engage as citizens and professionals in a world that continues to change and evolve. Humans are naturally curious beings and statistics is a language that can be used to better answer questions about personal choices and/or make sense of naturally occurring phenomena. Statistics is a way to ask questions, explore, and make sense of the world around us.

The Framework for Statistical Reasoning should be used in all grade levels and courses to guide learners through the sense-making process, ultimately leading to the goal of statistical literacy in all grade levels and courses. Reasoning with statistics provides a context that necessitates the learning and application of a variety of mathematical concepts.

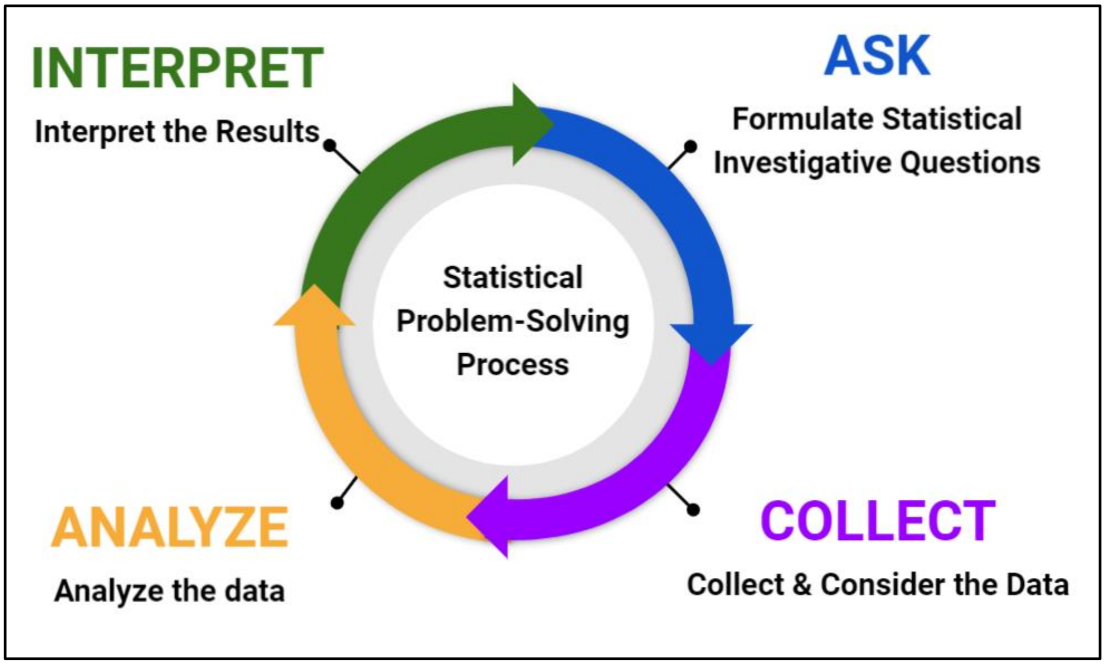


Figure 1: Georgia Framework for Statistical Reasoning

The following four-step statistical problem-solving process can be used throughout each grade level and course to help learners develop a solid foundation in statistical reasoning and literacy:

I. Formulate Statistical Investigative Questions
Ask questions that anticipate variability.

II. Collect & Consider the Data
Ensure that data collection designs acknowledge variability.

III. Analyze the Data
Make sense of data and communicate what the data mean using pictures (graphs) and words. Give an accounting of variability, as appropriate.

IV. Interpret the Results
Answer statistical investigative questions based on the collected data.