Louisiana STUDENT STANDARDS MATHEMATICS

Algebra I

Louisiana Student Standards: Companion Document for Teachers 2.0

This document is designed to assist educators in interpreting and implementing the Louisiana Student Standards for Mathematics. Found here are descriptions of each standard which answer questions about the standard's meaning and application to student understanding. Also included are the intended level of rigor and coherence links to prerequisite and corequisite standards. Examples are samples only and should not be considered an exhaustive list.

Additional information on the Louisiana Student Standards for Mathematics, including how to read the standards' codes, a listing of standards for each grade or course, and links to additional resources, is available on the Louisiana Department of Education K-12 Math Planning Page. Please direct any questions to STEM@la.gov.

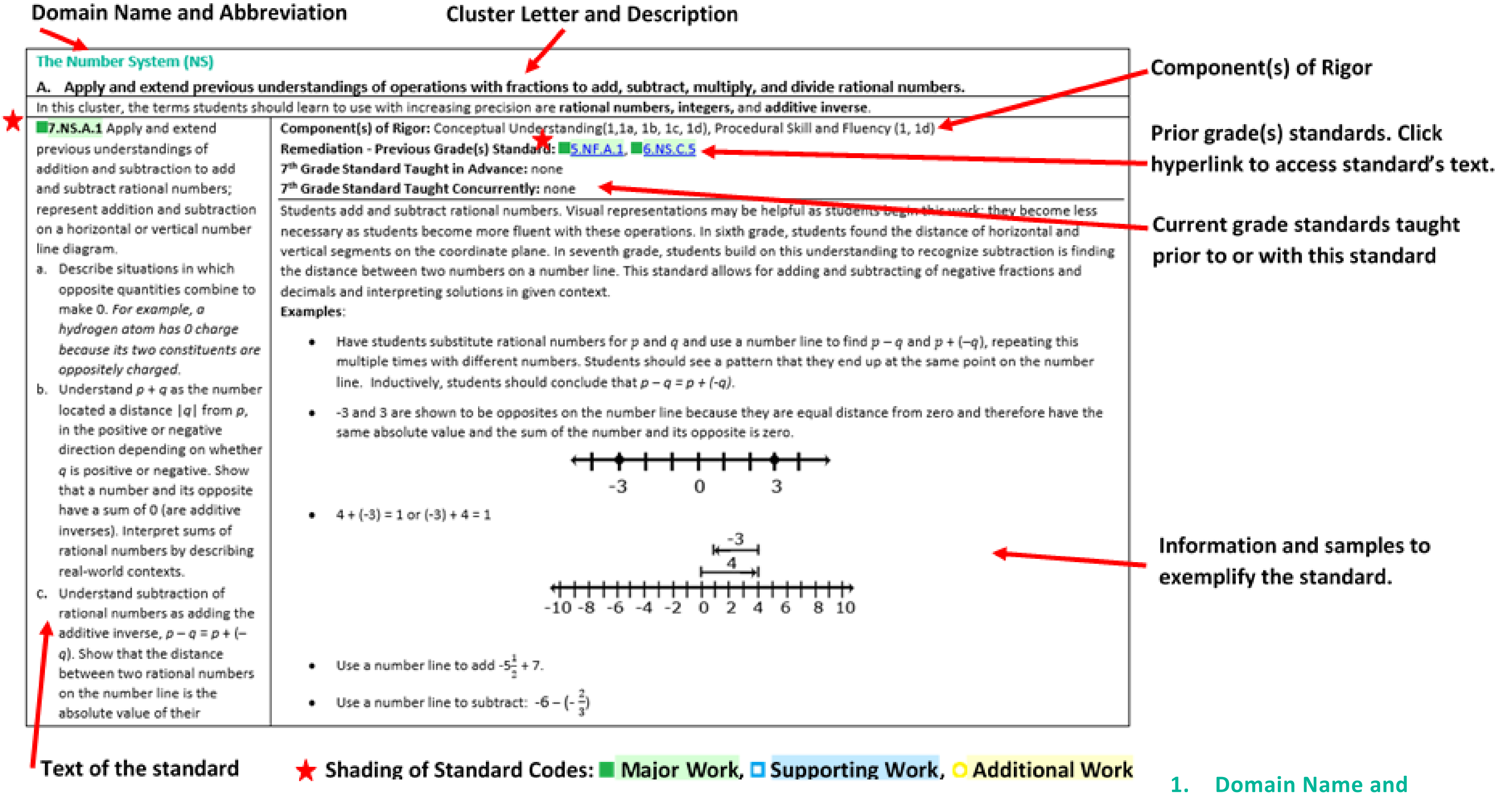
Updated August 15, 2022

DEPARTMENT of EDUCATION
Louisiana Believes

Table of Contents

How-to-Read Guide

The diagram below provides an overview of the information found in all companion documents. Definitions and more complete descriptions are provided on the next page.



The Number System (NS)

A. Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.

In this cluster, the terms students should learn to use with increasing precision are **rational numbers, integers,** and **additive inverse**.

🟩**7.NS.A.1** Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.

a. Describe situations in which opposite quantities combine to make 0. *For example, a hydrogen atom has 0 charge because its two constituents are oppositely charged.*

b. Understand $p + q$ as the number located a distance $|q|$ from p, in the positive or negative direction depending on whether q is positive or negative. Show that a number and its opposite have a sum of 0 (are additive inverses). Interpret sums of rational numbers by describing real-world contexts.

c. Understand subtraction of rational numbers as adding the additive inverse, $p – q = p + (–q)$. Show that the distance between two rational numbers on the number line is the absolute value of their

Component(s) of Rigor: Conceptual Understanding(1,1a, 1b, 1c, 1d), Procedural Skill and Fluency (1, 1d)

Remediation - Previous Grade(s) Standard: 🟩5.NF.A.1, 🟩6.NS.C.5

7th Grade Standard Taught in Advance: none

7th Grade Standard Taught Concurrently: none

Students add and subtract rational numbers. Visual representations may be helpful as students begin this work; they become less necessary as students become more fluent with these operations. In sixth grade, students found the distance of horizontal and vertical segments on the coordinate plane. In seventh grade, students build on this understanding to recognize subtraction is finding the distance between two numbers on a number line. This standard allows for adding and subtracting of negative fractions and decimals and interpreting solutions in given context.

Examples:

- Have students substitute rational numbers for p and q and use a number line to find $p – q$ and $p + (–q)$, repeating this multiple times with different numbers. Students should see a pattern that they end up at the same point on the number line. Inductively, students should conclude that $p – q = p + (-q)$.
- -3 and 3 are shown to be opposites on the number line because they are equal distance from zero and therefore have the same absolute value and the sum of the number and its opposite is zero.

- 4 + (-3) = 1 or (-3) + 4 = 1

- Use a number line to add $-5\frac{1}{2} + 7$.
- Use a number line to subtract: $-6 – (-\frac{2}{3})$

Domain Name and Abbreviation

Cluster Letter and Description

Component(s) of Rigor

Prior grade(s) standards. Click hyperlink to access standard's text.

Current grade standards taught prior to or with this standard

Information and samples to exemplify the standard.

Text of the standard

★ Shading of Standard Codes: 🟩 Major Work, ☐ Supporting Work, ○ Additional Work

1. **Domain Name and Abbreviation:** A grouping of standards consisting of related content that are further divided into clusters. Each domain has a unique abbreviation and is provided in parentheses beside the domain name.

2. **Cluster Letter and Description:** Each cluster within a domain begins with a letter. The description provides a general overview of the focus of the standards in the cluster.
3. **Previous Grade(s) Standards:** One or more standards that students should have mastered in previous grades to prepare them for the current grade standard. If students lack the pre-requisite knowledge and remediation is required, the previous grade standards provide a starting point.
4. **Standards Taught in Advance:** These current grade standards include skills or concepts on which the target standard is built. These standards are best taught before the target standard.
5. **Standards Taught Concurrently:** Standards which should be taught with the target standard to provide coherence and connectedness in instruction.
6. **Component(s) of Rigor:** See full explanation on components of rigor.
7. **Sample Problem:** The sample provides an example how a student might meet the requirements of the standard. Multiple examples are provided for some standards. However, sample problems should not be considered an exhaustive list. Explanations, when appropriate, are also included.
8. **Text of Standard:** The complete text of the targeted Louisiana Student Standards of Mathematics is provided.

Classification of Major, Supporting, and Additional Work

Students should spend the large majority of their time on the 🟩major work of the grade. □Supporting work and, where appropriate, ○additional work can engage students in the major work of the grade. Each standard is color-coded to quickly and simply determine how class time should be allocated. Furthermore, standards from previous grades that provide foundational skills for current grade standards are also color-coded to show whether those standards are classified as 🟩major, □supporting, or ○additional in their respective grades.

Components of Rigor

The K-12 mathematics standards lay the foundation that allows students to become mathematically proficient by focusing on conceptual understanding, procedural skill and fluency, and application.

Conceptual Understanding refers to understanding mathematical concepts, operations, and relations. It is more than knowing isolated facts and methods. Students should be able to make sense of why a mathematical idea is important and the kinds of contexts in which it is useful. It also allows students to connect prior knowledge to new ideas and concepts.

Procedural Skill and Fluency is the ability to apply procedures accurately, efficiently, and flexibly. It requires speed and accuracy in calculation while giving students opportunities to practice basic skills. Students' ability to solve more complex application tasks is dependent on procedural skill and fluency.

Application provides a valuable content for learning and the opportunity to solve problems in a relevant and a meaningful way. It is through real-world application that students learn to select an efficient method to find a solution, determine whether the solution makes sense by reasoning, and develop critical thinking skills.

Standards for Mathematical Practice

The Louisiana Standards for Mathematical Practice are expected to be integrated into every mathematics lesson for all students in grades K-12. Below are a few examples of how these practices may be integrated into tasks high school students complete.

Louisiana Standard	Explanations and Examples
HS.MP.1 Make sense of problems and persevere in solving them.	High school students start to examine problems by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. By high school, students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. They check their answers to problems using different methods and continually ask themselves, "Does this make sense?" They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.
HS.MP.2 Reason abstractly and quantitatively.	High school students seek to make sense of quantities and their relationships in problem situations. They abstract a given situation and represent it symbolically, manipulate the representing symbols, and pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Students use quantitative reasoning to create coherent representations of the problem at hand; consider the units involved; attend to the meaning of quantities, not just how to compute them; and know and flexibly use different properties of operations and objects.
HS.MP.3 Construct viable arguments and critique the reasoning of others.	High school students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. High school students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. High school students learn to determine domains, to which an argument applies, listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.
HS.MP.4 Model with mathematics.	High school students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. High school students make assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

Louisiana Standard	Explanations and Examples
HS.MP.5 Use appropriate tools strategically.	High school students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. High school students should be sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. They are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.
HS.MP.6 Attend to precision.	High school students try to communicate precisely to others by using clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, specifying units of measure, and label axes to clarify the correspondence between quantities in a problem. They calculate accurately and efficiently, expressing numerical answers with a degree of precision appropriate for the problem context. By the time they reach high school they have learned to examine claims and make explicit use of definitions.
HS.MP.7 Look for and make use of structure.	By high school, students look closely to discern a pattern or structure. In the expression $x^2 + 9x + 14$, older students can see the 14 as 2×7 and the 9 as $2 + 7$. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 - 3(x - y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y. High school students use these patterns to create equivalent expressions, factor and solve equations, and compose functions, and transform figures.
HS.MP.8 Look for and express regularity in repeated reasoning.	High school students notice if calculations are repeated, and look both for general methods and for shortcuts. Noticing the regularity in the way terms cancel when expanding $(x - 1)(x + 1)$, $(x - 1)(x^2 + x + 1)$, and $(x - 1)(x^3 + x^2 + x + 1)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, derive formulas or make generalizations, high school students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.

Modeling Standards

Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by a star symbol (★).

What is modeling?

Modeling links classroom mathematics and statistics to everyday life, work, and decision-making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. Quantities and their relationships in physical, economic, public policy, social, and everyday situations can be modeled using mathematical and statistical methods. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data.

A model can be very simple, such as writing total cost as a product of unit price and number bought, or using a geometric shape to describe a physical object like a coin. Even such simple models involve making choices. It is up to us whether to model a coin as a three-dimensional cylinder, or whether a two-dimensional disk works well enough for our purposes. Other situations—modeling a delivery route, a production schedule, or a comparison of loan amortizations—need more elaborate models that use other tools from the mathematical sciences. Real-world situations are not organized and labeled for analysis; formulating tractable models, representing such models, and analyzing them is appropriately a creative process. Like every such process, this depends on acquired expertise as well as creativity.

Some examples of such situations might include:

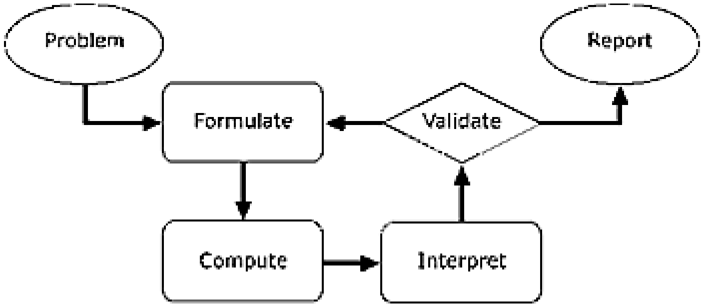
- Estimate how much water and food is needed for emergency relief in a devastated city of 3 million people, and how it might be distributed.
- Plan a table tennis tournament for 7 players at a club with 4 tables, where each player plays against each other player.
- Design the layout of the stalls in a school fair so as to raise as much money as possible.
- Analyze the stopping distance for a car.
- Model a savings account balance, bacterial colony growth, or investment growth.
- Engage in critical path analysis, e.g., applied to turnaround of an aircraft at an airport.
- Analyze the risk in situations such as extreme sports, pandemics, and terrorism.
- Relate population statistics to individual predictions.

In situations like these, the models devised depend on a number of factors: How precise an answer do we want or need? What aspects of the situation do we most need to understand, control, or optimize? What resources of time and tools do we have? The range of models that we can create and analyze is also constrained by the limitations of our mathematical, statistical, and technical skills, and our ability to recognize significant variables and relationships among them.

Diagrams of various kinds, spreadsheets and other technology, and algebra are powerful tools for understanding and solving problems drawn from different types of real-world situations.

One of the insights provided by mathematical modeling is that essentially the same mathematical or statistical structure can sometimes model seemingly different situations. Models can also shed light on the mathematical structures themselves, for example, as when a model of bacterial growth makes more vivid the explosive growth of the exponential function.

The basic modeling cycle is summarized in the diagram. It involves (1) identifying variables in the situation and selecting those that represent essential features, (2) formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables, (3) analyzing and performing operations on these relationships to draw conclusions, (4) interpreting the results of the mathematics in terms of the original situation, (5) validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable, (6) reporting on the conclusions and the reasoning behind them. Choices, assumptions, and approximations are present throughout this cycle.



In descriptive modeling, a model simply describes the phenomena or summarizes them in a compact form. Graphs of observations are a familiar descriptive model—for example, graphs of global temperature and atmospheric CO_2 over time.

Analytic modeling seeks to explain data on the basis of deeper theoretical ideas, albeit with parameters which are empirically based; for example, exponential growth of bacterial colonies (until cut-off mechanisms such as pollution or starvation intervene) follows from a constant reproduction rate. Functions are an important tool for analyzing such problems.

Graphing utilities, spreadsheets, computer algebra systems, and dynamic geometry software are powerful tools that can be used to model purely mathematical phenomena (e.g., the behavior of polynomials) as well as physical phenomena).

Number and Quantity: The Real Number System (N-RN)

B. Use properties of rational and irrational numbers.

In this cluster, the terms students should learn to use with increasing precision are **rational and irrational numbers.**

Louisiana Standard	**Explanations and Examples**
○ **A1: N-RN.B.3** Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** □8.NS.A.1 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** none Since every difference can be rewritten as a sum and every quotient as a product, this includes differences and quotients as well. Explaining why the four operations on rational numbers produce rational numbers can be a review of students understanding of fractions and negative numbers. Many students will already have the required understanding but have likely not studied it formally, nor been pushed to articulate their reasoning. Rather than directly instruct students of these facts, students should be given opportunities to explore, make conjectures, and guided to test their conjectures, resulting in a deeper understanding than would be produced from direct instruction. **Example:** • Operations with Rational and Irrational Numbers: https://www.illustrativemathematics.org/content-standards/HSN/RN/B/3/tasks/690 • Sums of rational and irrational numbers: https://www.illustrativemathematics.org/content-standards/HSN/RN/B/3/tasks/1817

Number and Quantity: Quantities (N-Q)

A. Reason quantitatively and use units to solve problems.

In this cluster, the terms students should learn to use with increasing precision are **interpret units**, **descriptive modeling**, **error, tolerance, and level of accuracy.**

Louisiana Standard	Explanations and Examples
🟦**A1: N-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. ★	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** 🟩6.RP.A.3 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** 🟦A1: N-Q.A.2 **Example:** • Harvesting the Field: https://www.illustrativemathematics.org/content-standards/HSN/Q/A/1/tasks/83
🟦**A1: N-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. ★	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** 🟦A1: N-Q.A.1 **Example:** • Giving Raises: https://www.illustrativemathematics.org/content-standards/HSN/Q/A/2/tasks/1850
🟦**A1: N-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. ★	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** 🟩8.EE.A.4 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** none The margin of error and tolerance limit varies according to the measure, tool used, and context. **Example:** • Weed Killer: https://www.illustrativemathematics.org/content-standards/HSN/Q/A/2/tasks/81

Algebra: Seeing Structure in Expressions (A-SSE)

A. Interpret the structure of expressions.

In this cluster, the terms students should learn to use with increasing precision are **expression, term, factor, coefficient, and rewrite an expression in a different form.**

Louisiana Standard	Explanations and Examples
🟩**A1: A-SSE.A.1** Interpret expressions that represent a quantity in terms of its context.★ a. Interpret parts of an expression, such as terms, factors, and coefficients. b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret* $P(1+r)^n$ *as the product of P and a factor not depending on P.*	**Component(s) of Rigor:** Conceptual Understanding (1, 1a, 1b) **Remediation - Previous Grade(s) Standard:** 🟩6.EE.A.2, 🟩7.EE.A.2 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** none Students should understand the vocabulary for the parts that make up the whole expression and be able to identify those parts and interpret their meaning in terms of a context. Students: • *Use* appropriate vocabulary for the parts that make up the whole expression. • *Identify* the different parts of the expression and explain their meaning within the context of a problem. • *Decompose* expressions and make sense of the multiple factors and terms by explaining the meaning of the individual parts. **Example**: • Seeing Dots: https://www.illustrativemathematics.org/content-standards/HSA/SSE/A/1/tasks/21 Students interpret complicated expressions by viewing one or more of their parts as a single entity. **Examples:** • The Physics Professor: https://www.illustrativemathematics.org/content-standards/HSA/SSE/A/1/tasks/23 • Given that I, income from a concert, is the price, p, of a ticket times each person in attendance, consider the equation $I = 4000p - 250p^2$ that represents income from a concert where p is the price per ticket. (The equivalent factored form, $p(4000 - 250p)$, shows that the income can be interpreted as the price times the number of people in attendance based on the price charged. Students recognize $(4000 - 250p)$ as a single quantity for the number of people in attendance.*)* • The expression $10{,}000(1.055)^n$ is the amount of money in an investment account with interest compounded annually for n years. Determine the initial investment and the annual interest rate. (The factor of 1.055 can be rewritten as (1 + 0.055), revealing the growth rate of 5.5% per year.)

🟩**A1: A-SSE.A.2** Use the structure of an expression to identify ways to rewrite it. *For example, see* $x^4 - y^4$ *as* $(x^2)^2 - (y^2)^2$, *thus recognizing it as a difference of squares that can be factored as* $(x^2 - y^2)(x^2 + y^2)$, *or see* $2x^2 + 8x$ *as* $(2x)(x) + 2x(4)$, *thus recognizing it as a polynomial whose terms are products of monomials and the polynomial can be factored as* $2x(x+4)$.	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** 🟩6.EE.A.3, 🟩7.EE.A.1 **Algebra I Standard Taught in Advance:** 🟩A1: A-SSE.A.1 **Algebra I Standard Taught Concurrently:** none
	Example: • Equivalent Expressions: https://www.illustrativemathematics.org/content-standards/HSA/SSE/A/2/tasks/87

Algebra: Seeing Structure in Expressions (A-SSE)

B. Write expressions in equivalent forms to solve problems.

In this cluster, the terms students should learn to use with increasing precision are **equivalent form of an expression; factor and complete the square of a quadratic expression, and properties of exponents.**

Louisiana Standard	Explanations and Examples
☐**A1: A-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.★ a. Factor a quadratic expression to reveal the zeros of the function it defines. b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. c. Use the properties of exponents to transform expressions for exponential functions emphasizing integer exponents. *For example, the growth of bacteria can be modeled by either* $f(t) = 3^{(t+2)}$ *or* $g(t) = 9(3^t)$ *because the expression* $3^{(t+2)}$ *can be rewritten as* $(3^t)(3^2) = 9(3^t)$.	**Component(s) of Rigor:** Conceptual Understanding (3, 3a, 3b), Procedural Skill and Fluency (3, 3a, 3b, 3c) **Remediation - Previous Grade(s) Standard:** 🟩6.EE.A.3, 🟩7.EE.A.1, 🟩8.EE.A.1 **Algebra I Standard Taught in Advance:** 🟩A1: A-SSE.A.1, 🟩A1: A-SSE.A.2 **Algebra I Standard Taught Concurrently:** 🟩A1: A-REI.B.4 Students factor quadratic expressions and find the zeroes of the quadratic function they represent. Students explain the meaning of the zeroes as they relate to the problem. **Example:** • Profit of a Company: https://www.illustrativemathematics.org/content-standards/HSA/SSE/B/3/tasks/434 Students use completing the square to rewrite a quadratic expression in the form $y = a(x - h)^2 + k$ to identify the vertex of the parabola (h, k) and explain its meaning in context. This implies a thorough understanding of when it is appropriate to use vertex form; thus students should use this strategy when looking for the maximum or minimum value. **Example:** • Profit of a company, assessment variation: https://www.illustrativemathematics.org/content-standards/HSA/SSE/B/3/tasks/1344 Students use properties of exponents to transform expressions for exponential functions. **Example:** • Ice Cream: https://www.illustrativemathematics.org/content-standards/HSA/SSE/B/3/tasks/551

Algebra: Arithmetic with Polynomials and Rational Expressions (A-APR)

A. Perform arithmetic operations on polynomials.

In this cluster, the terms students should learn to use with increasing precision are **polynomial and operations on polynomials.**

Louisiana Standard	Explanations and Examples
🟩**A1: A-APR.A.1** Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** 🟩6.EE.A.3, 🟩6.EE.A.4, 🟩7.EE.A.1, 🟩8.EE.A.1 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** none The primary strategy for this cluster is to make connections between arithmetic of integers and arithmetic of polynomials. In order to understand this standard, students need to work toward both understanding and fluency with polynomial arithmetic. Furthermore, to talk about their work, students will need to use correct vocabulary, such as integer, monomial, polynomial, factor, and term. **Examples:** • Simplify each of the following: a. $(4x + 3) - (2x + 1)$ b. $(x^2 + 5x - 9) + 2x(4x - 3)$

<table>
<tr><td colspan="2">Algebra: Arithmetic with Polynomials and Rational Expressions (A-APR)
B. Understand the relationship between zeros and factors of polynomials.</td></tr>
<tr><td colspan="2">In this cluster, the terms students should learn to use with increasing precision are zeros and sketching of a quadratic function.</td></tr>
<tr><td>Louisiana Standard</td><td>Explanations and Examples</td></tr>
<tr><td>🟦A1: A-APR.B.3 Identify zeros of quadratic functions and use the zeros to sketch a graph of the function defined by the polynomial.</td><td>Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency
Remediation - Previous Grade(s) Standard: 🟩7.EE.A.1
Algebra I Standard Taught in Advance: 🟩A1: A-SSE.A.2, 🟦A1:SSE.B.3
Algebra I Standard Taught Concurrently: none
This standard calls for a sketch of the graph after zeros are identified. Sketching implies that the graph should be done by hand rather than generated by a graphing calculator.
Examples:
• Given the function $f(x) = (x - 3)(x + 4)$, list the zeroes of the function and sketch the graph.
• Sketch the graph of the function, $f(x) = (x + 5)^2$. How many zeros does this function have? Explain.</td></tr>
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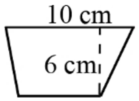
Algebra: Creating Equations ★ (A-CED)

A. Create equations that describe numbers or relationships.

In this cluster, the terms students should learn to use with increasing precision are **equations and inequalities in one variable, equations in two variables, systems of equations/inequalities, exponential equation, and rearrange a formula.**

Louisiana Standard	Explanations and Examples
🟩**A1: A-CED.A.1** Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear, quadratic, and exponential functions.* ★	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency, Application **Remediation - Previous Grade(s) Standard:** 🟩7.EE.B.4, 🟩8.EE.C.7 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** 🟩A1: A-REI.A.1, 🟩A1:A-REI.B.3 Equations can represent real world and mathematical problems. Include equations and inequalities that arise when comparing the values of two different functions, such as one describing linear growth and one describing exponential growth. **Examples:** • To be considered a 'fuel efficient' vehicle, a car must get more than 30 miles per gallon. Consider a test run of 200 miles. How many gallons of fuel can a car use and be considered 'fuel-efficient'? • Given that the following trapezoid has an area of 54 cm^2, set up an equation to find the length of the base, and solve the equation.  • Lava coming from the eruption of a volcano follows a parabolic path. The height *h* in feet of lava *t* seconds after it is ejected from the volcano is given by $h(t) = -t^2 + 16t + 936$. After how many seconds does the lava reach its maximum height of 1000 feet? • A rental agreement locks the monthly rent of an apartment to a constant value for one year. The average rate to rent an apartment is \$750 per month and increases at an inflation rate of 8% per year. If inflation continues at the current rate, on which year will the rent be at least \$1000 per month?

🟩**A1: A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. ★

Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency
Remediation - Previous Grade(s) Standard: 🟩8.EE.C.8, 🟩8.F.A.3, ◻8.F.B.4
Algebra I Standard Taught in Advance: 🟩A1: A-CED.A.1
Algebra I Standard Taught Concurrently: 🟩A1: A-REI.D.10

Students:

- Create equations in two variables.
- Graph equations on coordinate axes with labels and scales clearly labeling the axes, defining what the values on the axes represent and the unit of measure.
- Select intervals for the scale that are appropriate for the context and display adequate information about the relationship.
- Choose appropriate minimum and maximum values for a graph.

Linear equations can be written in a multitude of ways; $y = mx + b$ and $ax + by = c$ are commonly used forms (given that *x* and *y* are the two variables). Students should be flexible in using multiple forms and recognizing from the context, which is appropriate to use in creating the equation. Time spent manipulating linear equations from one form to another is fruitless; moreover, students should be able to graph from either form listed above.

Examples:

- At a fundraising event, the FFA sold hot dogs for $1.50 and drinks for $2.00. The FFA earned $400 at the fundraiser.
  a. Write an equation to calculate the total of $400 based on the hot dog and drink sales.
  b. Graph the relationship between hot dog sales and drink sales.
- A spring with an initial length of 25 cm will compress 0.5 cm for each pound applied.
  a. Write an equation to model the relationship between the amount of weight applied and the length of the spring.
  b. Graph the relationship between pounds and length.
  c. What does the graph reveal about limitation on weight?

Quadratic equations can be written in a multitude of ways; $y = ax^2 + bx + c$ and $y = k(x + m)(x + n)$ are commonly used forms (given that *x* and *y* are the two variables). Students should be flexible in using multiple forms and recognizing from the context, which is appropriate to use in creating the equation. As with linear equations, time spent manipulating quadratic equations from one form to another is mostly fruitless; moreover, students should be able to graph from either form listed above.

Examples:

- Throwing a Ball: https://www.illustrativemathematics.org/content-standards/HSA/CED/A/2/tasks/437
- The local park is designing a new rectangular sandlot. The sandlot is to be twice as long as the original square sandlot and 3 feet less than its current width. What must be true of the original square lot to justify that the new rectangular lot has more

🟩**A1: A-CED.A.2** *continued*	area? Note**:** Students can construct the equations for each area and graph each equation. Students should select scales for the length of the original square and the area of the lots suitable for the context. **Exponential equations** can be written in different ways; $y = ab^x$and $y = a\ (1 \pm r)^x$ are the most common forms (given that *x* and *y* are variables). Students should be flexible in using all forms and recognizing from the context which is appropriate to use in creating the equation. **Example:** • In a woman's professional tennis tournament, the money a player wins depends on her finishing place in the standings. The first-place finisher wins half of $1,500,000 in total prize money. The second-place finisher wins half of what is left; then the third-place finisher wins half of that, and so on. a. Write a rule to calculate the actual prize money in dollars won by the player finishing in nth place, for any positive integer n. b. Graph the relationship between the first 10 finishers and the prize money in dollars. *c.* What pattern is indicated in the graph? What type of relationship exists between the two variables?
🟩**A1: A-CED.A.3** Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* ★	**Component(s) of Rigor:** Conceptual Understanding, Application **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** 🟩A1: A-CED.A.1, 🟩A1: A-CED.A.2, 🟩A1: A-REI.D.10 **Algebra I Standard Taught Concurrently:** none Students recognize when a constraint can be modeled with an equation, inequality, or system of equations/inequalities. These constraints may be stated directly or be implied through the context of the given situation. In Algebra I, focus on linear equations and inequalities. Students should approach optimization problems using a problem-solving process, such as using a table. **Examples:** • A club is selling hats and jackets as a fundraiser. Their budget is $1500, and they want to order at least 250 items. They must buy at least as many hats as they buy jackets. Each hat costs $5, and each jacket costs $8. a. Write a system of inequalities to represent the situation. b. If the club buys 150 hats and 100 jackets, will the conditions be satisfied?

🟩**A1: A-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law $V = IR$ to highlight resistance R.*★	**Component(s) of Rigor:** Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** 🟩A1: A-CED.A.2 **Algebra I Standard Taught Concurrently:** 🟩A1: A-REI.A.1, 🟩A1: A-REI.B.3
	Students solve multi-variable formulas for a specific variable. In Algebra I, limit to formulas that are linear in the variable of interest, or to formulas involving squared or cubed variables. Explicitly connect this to the process of solving equations using inverse operations. **Examples:** • The Pythagorean Theorem expresses the relation between legs a and b of a right triangle and its hypotenuse c with the equation $a^2 + b^2 = c^2$. a. Why might the theorem need to be solved for c? b. Solve the equation for c and write a problem situation where this form of the equation might be useful. • Solve $V = \frac{4}{3}\pi r^3$ for radius ***r*.** • Motion can be described by the formula $s = ut + \frac{1}{2}at^2$, where t = time elapsed, u = initial velocity, a = acceleration, and s = distance traveled. a. Why might the equation need to be rewritten in terms of a? b. Rewrite the equation in terms of a.

<table>
<tr><td colspan="2">Algebra: Reasoning with Equations and Inequalities ★ (A-REI)
Understand solving equations as a process of reasoning and explain the reasoning.</td></tr>
<tr><td colspan="2">In this cluster, the terms students should learn to use with increasing precision are properties of equations, explain each step in solving an equation, and construct a viable solution.</td></tr>
<tr><td>Louisiana Standard</td><td>Explanations and Examples</td></tr>
<tr><td>🟩A1: A-REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.</td>
<td>Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: 🟩7.EE.B.4, 🟩8.EE.C.7
Algebra I Taught in Advance: none
Algebra I Taught Concurrently: 🟩A1: A-CED.A.1, 🟩A1: A-CED.A.4, 🟩A1: A-REI.B.3, 🟩A1: A-REI.B.4
<hr>
Students should focus on solving all applicable equation types presented in Algebra I and be able to extend and apply their reasoning to other types of equations in future courses. When solving equations, students will use the properties of equality to justify and explain each step obtained from the previous step, assuming the original equation has a solution, and develop an argument that justifies their method.

Examples:

Assuming an equation has a solution; construct a convincing argument that justifies each step in the solution process. Justifications may include the associative, commutative, division and identity properties, combining like terms, etc.
<table>
<tr><th>Steps</th><th>Justification</th></tr>
<tr><td>$5(x+3)-3x=55$</td><td>Given equation</td></tr>
<tr><td>$5x+15-3x=55$</td><td>Distributive property</td></tr>
<tr><td>$2x+15=55$</td><td>Combined like terms</td></tr>
<tr><td>$2x+15-15=55-15$</td><td>Subtraction property of equality</td></tr>
<tr><td>$2x=40$</td><td>Result of a subtracting</td></tr>
<tr><td>$\frac{2x}{2}=\frac{40}{2}$</td><td>Division property of equality</td></tr>
<tr><td>$x=20$</td><td>Result of division</td></tr>
</table>

For quadratic examples, see Zero Product Property 4: https://www.illustrativemathematics.org/content-standards/tasks/2144

</td></tr>
</table>

Algebra: Reasoning with Equations and Inequalities ★ (A-REI)

B. Solve equations and inequalities in one variable.

In this cluster, the terms students should learn to use with increasing precision are **linear equations and inequalities in one variable, solve a quadratic by completing the square, and solve by inspection.**

Louisiana Standard	Explanations and Examples
🟩**A1: A-REI.B.3** Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.	**Component(s) of Rigor:** Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** 🟩7.EE.B.4, 🟩8.EE.C.7 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** 🟩A1: A-CED.A.1, 🟩A1: A-CED.A.4,🟩A1: A-REI.A.1, 🟩A1: A-REI.B.4 It is important to note that students have not solved linear inequalities since Grade 7 as there are no standards requiring such work in Grade 8. Furthermore, the work in Grade 7 was limited to two-step linear inequalities. Students should have explored the result of multiplying or dividing both sides of an inequality by a negative value but would likely benefit from a refresher on the topic. **Examples:** • Solve $ax + 7 = 12$ for x. • $\frac{3+x}{7} = \frac{x-9}{4}$ • Solve $(y - y_1) = m(x - x_1)$ for m.

🟩**A1: A-REI.B.4** Solve quadratic equations in one variable. a. Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x-p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form. b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as *“no real solution.”*	**Component(s) of Rigor:** Conceptual Understanding (4b) Procedural Skill and Fluency (4, 4a, 4b) **Remediation - Previous Grade(s) Standard:** 🟩7.EE.A.1, 🟩8.EE.A.2 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** ◻A1: A-SSE.B.3, 🟩A1: A-CED.A.1, 🟩A1: A-REI.A.1, 🟩A1: A-REI.B.3 The zero product property is used to explain why the factors are set equal to zero. A natural extension would be to relate the type of solutions to $ax^2 + bx + c = 0$ to the behavior of the graph of $y = ax^2 + bx + c$. **Students in Algebra I should recognize when roots are complex and indicate that there are no real solutions rather than writing in $\boldsymbol{a \pm bi}$ form.** **Examples:** • Determine the type of roots for the equation $2x^2 + 5 = 2x$? Explain how you know. • What is the nature of the roots of $x^2 + 6x + 10 = 0$? Solve the equation using the quadratic formula and completing the square. How are the two methods related?

Algebra: Reasoning with Equations and Inequalities ★ (A-REI)

C. Solve systems of equations.

In this cluster, the terms students should learn to use with increasing precision are **multiple of an equation, sum of two equations, and solve a system of equations exactly and approximately.**

Louisiana Standard

○**A1: A-REI.C.5** Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

Explanations and Examples

Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: 🟩8.EE.C.8
Algebra I Standard Taught in Advance: none
Algebra I Standard Taught Concurrently: ○A1: A-REI.C.6

The focus of this standard is to provide mathematical justification for the addition (elimination) method of solving systems of equations, ultimately transforming a given system of two equations into a simpler equivalent system that has the same solutions as the original system. This work builds on student experiences in graphing and solving systems of linear equations from middle school to focus on justification of the methods used.

Example:

- Use the system for problems a – d.

$$\begin{cases} 2x + y = 13 \\ x + y = 10 \end{cases}$$

a. Graph the given system of linear equations. Describe the solution of the system and how it relates to the solutions of each individual equation.

b. Add the two linear equations together and graph the resulting equation. Describe the solutions to the new equation and how they relate to the system's solution.

c. Explore what happens with other combinations such as:
   i. Multiply the first equation by 2 and add to the second equation
   ii. Multiply the second equation by -2 and add to the first equation
   iii. Multiply the second equation by -1 and add to the first equation
   iv. Multiply the first equation by -1 and add to the second equation

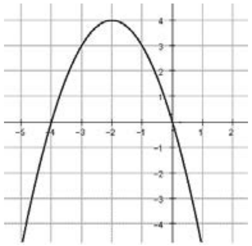
d. Make a conjecture about the solution to a system of linear equations when one equation is multiplied by a given number and then added to the other equation.

○**A1: A-REI.C.6** Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.	**Component(s) of Rigor:** Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** 🟩8.EE.C.8 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** ○A1: A-REI.C.5 The solution methods can include but are not limited to graphical, elimination/linear combination, and substitution. While this standard simply calls for procedural skill and fluency in solving systems of linear equations, it is appropriate to provide students with experiences connecting this work to the A-CED domain. Students may use graphing calculators, programs, or applets to model and find approximate solutions for systems of equations. **Example:** • Solve the system of equations. Use a second method to verify your answer. $\begin{cases} x + y = 11 \\ 3x - y = 5 \end{cases}$

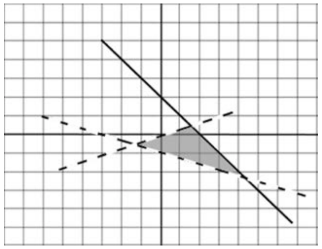
Algebra: Reasoning with Equations and Inequalities ★ (A-REI)

D. Represent and solve equations and inequalities graphically.

In this cluster, the terms students should learn to use with increasing precision are **solution of an equation, solution of a system of equations, rational function, piecewise function, absolute value function, exponential function, graph the solution to an inequality in two variables in a half plane, and set notation for a system of inequalities.**

Louisiana Standard	**Explanations and Examples**
🟩**A1: A-REI.D.10** Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** 🟩8.EE.B.5 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** 🟩A1: A-CED.A.2 In Algebra I, students focus on linear, quadratic, and exponential equations and are able to adapt and apply that learning to other types of equations in future courses. Students can explain and verify that every point (x, y) on the graph of an equation represents all values for x and y that make the equation true. **Examples:** • Which of the following points are on the graph of the equation $-5x + 2y = 20$? How many points are on this graph? Explain. a. $(4, 0)$ b. $(0, 10)$ c. $(-1, 7.5)$ d. $(2.3, 5)$ • Verify that (-1, 60) is a solution to the equation, $y = 15\left(\frac{1}{4}\right)^x$. Explain what this means for the graph of the function. • Given the graph of $y = g(x)$, provide at least three solutions to $g(x) = y$. 

🟩**A1: A-REI.D.11** Explain why the *x*-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, piecewise linear (to include absolute value), and exponential functions. ★	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** 🟩8.EE.C.8 **Algebra I Standard Taught in Advance:** ○A1: A-REI.C.6, 🟩A1: REI.D.10 **Algebra I Standard Taught Concurrently:** none Because A1:REI.D.11 permits the use of technology to graph functions, the standard allows for students to solve equations that, algebraically, would be too advanced. Teachers should view this as a systems of equations standard that applies to linear, polynomial, rational, piecewise linear (to include absolute value) and exponential functions, with students understanding that intersection points of graphs are solutions to both equations. Students would benefit by having access to a calculator or an application with graphing capabilities. **Example:** • Find the solution to the following system of equations. Solution ($x \approx 5.5, y \approx 5.2$) $\left\{\begin{matrix} y = x^2 - 4x - 3 \\ y = x^3 - 4x^2 - 6x - 7 \end{matrix}\right\}$

🟩**A1: A-REI.D.12** Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.	**Component(s) of Rigor:** Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** ○A1: A-REI.C.6, 🟩A1: REI.D.10 **Algebra I Standard Taught Concurrently:** none **Examples:** - Graph the solution: $y \leq 2x + 3$. - Graph the system of linear inequalities below and determine if (3, 2) is a solution to the system. $\begin{cases} x - 3y > 0 \\ x + y \leq 2 \\ x + 3y > -3 \end{cases}$ Solution: 

Functions: Interpreting Functions (F-IF)

A. Understand the concept of a function and use function notation.

In this cluster, the terms students should learn to use with increasing precision are **domain, range, function notation, input, output, evaluate a function, arithmetic sequence, and geometric sequence.**

Louisiana Standard

🟩**A1: F-IF.A.1** Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.

Explanations and Examples

Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: 🟩8.F.A.1, 🟩8.F.A.2, 🟩8.F.A.3
Algebra I Standard Taught in Advance: none
Algebra I Standard Taught Concurrently: none

The foundation for this standard are the standards in 8.F.A; however, this is students' first opportunity to work with function notation as it is explicitly left out of the Grade 8 standards.

Example:

- Determine which of the following tables represent a function and explain why.

Table A

x	y
0	1
1	2
2	2
3	4

Table B

r	T
0	0
1	2
1	3
4	5

Given the function, f, students explain that input values are guaranteed to produce unique output values and use the function rule to generate a table or graph. They identify x as an element of the domain, the input, and $f(x)$ as an element in the range, the output. Students recognize that the graph of the function, f, is the graph of the equation $y = f(x)$ and that $(x, f(x))$ is a point on the graph of f.

Example:

- A pack of pencils cost $0.75. If n is the number of packs purchased, then the total purchase price is represented by the function $t(n) = 0.75n$.
  a. Explain why t is a function.
  b. What is a reasonable domain and range for the function t?
  c. Graph function t.

🟩**A1: F-IF.A.2** Use function notations, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** 🟩6.EE.A.2 **Algebra I Standard Taught in Advance:** 🟩A1: F-IF.A.1 **Algebra I Standard Taught Concurrently:** none **Examples:** • Evaluate $f(2)$ for the function $f(x) = 5(x-3) + 17$, both graphically and algebraically. • Evaluate $f(2)$ for the function $f(x) = 1200(1+.04)^x$, both graphically and algebraically. • You placed a yam in the oven and, after 45 minutes, you take it out. Let f be the function that assigns to each minute after you placed the yam in the oven, its temperature in degrees Fahrenheit. Write a sentence for each of the following to explain what it means in everyday language. a. $f(0) = 65$ b. $f(5) < f(10)$ c. $f(40) = f(45)$ d. $f(45) > f(60)$ • The rule $f(x) = 50(0.85)^x$represents the amount of a drug in milligrams, $f(x)$, which remains in the bloodstream after x hours. Evaluate and interpret each of the following: a. $f(0)$ b. $f(x) < 6$ • If $h(t) = -16t^2 + 5t + 7$ models the path of an object projected into the air where t is time in seconds and $h(t)$ is the vertical height in feet. a. Find $h(5)$ and explain the meaning of the solution. b. Find t when $h(t) = 0$. Explain the meaning of the solution.

🟩**A1: F-IF.A.3** Recognize that sequences are functions whose domain is a subset of the integers. Relate arithmetic sequences to linear functions and geometric sequences to exponential functions.	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** 🟩A1: F-IF.A.1, 🟩A1:F-IF.A.2 **Algebra I Standard Taught Concurrently:** ◻A1: F-BF.A.1 A sequence can be described as a function, with the input numbers consisting of a subset of the integers, and the output numbers being the terms of the sequence. The most common subset for the domain of a sequence is the Natural numbers {1, 2, 3, …}; however, there are instances where it is necessary to include {0} or possibly negative integers. Whereas, some sequences can be expressed explicitly, there are those that are a function of the previous terms. In which case, it is necessary to provide the first few terms to establish the relationship. Students recognize that arithmetic sequences are linear functions and geometric sequences are exponential functions. As such, consecutive terms in an arithmetic sequence have a common difference (e.g., 1, 3, 5, 7…is generated by adding 2 to the previous term; thus, the common difference is 2). Consecutive terms in a geometric sequence have the same ratio (e.g., 1, 3, 9, 27, 81 is generated by multiplying the previous term by a factor of 3; therefore, the comon ratio is 3:1).

Functions: Interpreting Functions (F-IF)

B. Interpret functions that arise in applications in terms of the context.

In this cluster, the terms students should learn to use with increasing precision are **linear, piecewise linear, absolute value, quadratic and exponential functions; domain, intercepts, intervals, maximum, minimum, symmetry, and end behavior; and average rate of change for listed functions.**

Louisiana Standard

🟩**A1: F-IF.B.4** For linear, piecewise linear (to include absolute value), quadratic, and exponential functions that model a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; and end behavior.* ★

Explanations and Examples

Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: ◻8.F.B.5
Algebra I Standard Taught in Advance: 🟩A1: F-IF.A.1, ◻A1: N-Q.A.1
Algebra I Standard Taught Concurrently: None

Students interpret the key features of the different functions listed in the standard. When given a table or graph of a function that models a real-life situation, explain the meaning of the characteristics of the table or graph in the context of the problem.

Key features

- of a linear function are slope and intercepts
- of a quadratic function are intervals of increase/decrease, positive/negative, maximum/minimum, symmetry, and intercepts
- of an exponential function include y-intercept and increasing/decreasing itervals
- of an absolute value include y-intercept, minimum or maximum, increasing or decreasing intervals, and symmetry

Examples:

- The local newspaper charges for advertisements in their community section. A customer has called to ask about the charges. The newspaper gives the first 50 words for free and then charges a fee per word. Use the table at the right to describe how the newspaper charges for the ads. Include all important information.

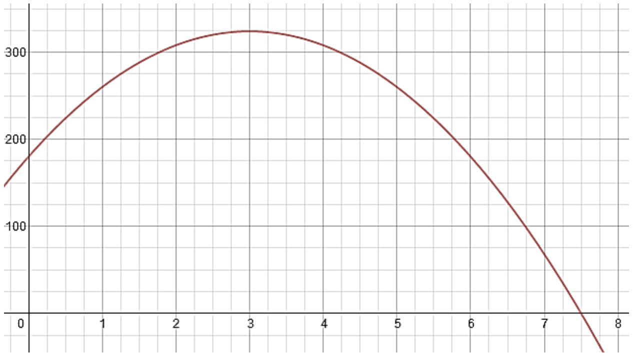
# of words	50	60	70	80	90	100
Cost ($)	0.00	0.50	1.00	1.50	2.00	2.50

🟩**A1: F-IF.B.4** *continued*

- The graph of $h(t) = -5t^2 + 10t + 3$, a function giving the height of a diver above the water (in meters), t seconds after the diver leaves the springboard, is shown to the right.

  a. How high above the water is the springboard? Justify your answer.
  b. When does the diver hit the water? Justify your answer.
  c. At what time on the diver's descent toward the water is the diver again at the same height as the springboard? Justify your answer.
  d. When does the diver reach the peak of the dive? Justify your answer.

- The graph represents the height (in feet) of a rocket as a function of the time (in seconds) since it was launched. Use the graph to answer the following:



  a. What is the appropriate domain for *t* in this context? Why?
  b. What is the height of the rocket two seconds after it was launched?
  c. What is the maximum value of the function and what does it mean in context?
  d. When is the rocket 100 feet above the ground?
  e. When is the rocket 250 feet above the ground?
  f. Why are there two answers to part e but only one practical answer for part d?
  g. What are the intercepts of this function? What do they mean in the context of this problem?
  h. What are the intervals of increase and decrease on the practical domain? What do they mean in the context of the problem?

- Jack planted a mysterious bean just outside his kitchen window. Jack kept a table (shown below) of the plant's growth. He measured the height at 8:00 am each day.

Day	0	1	2	3	4
Height (cm)	2.56	6.4	16	40	100

  a. What was the initial height of Jack's plant?
  b. How is the height changing each day?
  c. If this pattern continues, how tall should Jack's plant be after 8 days?

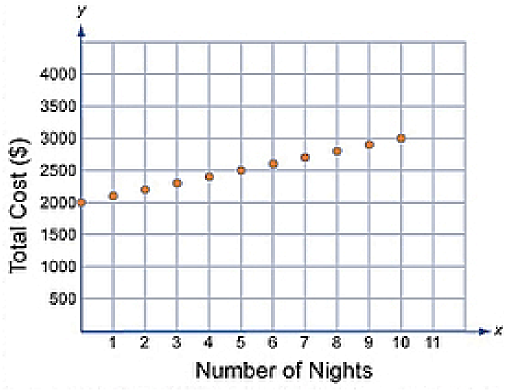
🟩**A1: F-IF.B.4** *continued*	- The front of a camping tent can be modeled by the function $y = -1.4\|x - 2.5\| + 3.5$ where x and y are measured in feet and the x-axis represents the ground. a. What does the point (2.5, 3.5) represent in the context of the situation? b. What are the height and width of the tent? c. What are the intervals of increase or decrease? What do they mean in the context of the problem?

🟩**A1: F-IF.B.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.* ★

Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: none
Algebra I Standard Taught in Advance: 🟩A1: F-IF.A.1, 🟩A1: F-IF.B.4
Algebra I Standard Taught Concurrently: none

Examples:

- An all-inclusive resort in Los Cabos, Mexico provides everything for their customers during their stay including food, lodging, and transportation. Use the graph below to describe the domain of the total cost function.



- Maggie tosses a coin off of a bridge into a stream below. The distance the coin is above the water is modeled by the equation $y = -16x^2 + 96x + 112$, where *x* represents time in seconds. What is a reasonable domain for the function?

- Oakland Coliseum Problem: https://www.illustrativemathematics.org/content-standards/HSF/IF/B/5/tasks/631

🟩**A1: F-IF.B.6** Calculate and interpret the average rate of change of a linear, quadratic, piecewise linear (to include absolute value), and exponential function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph. ★

Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency
Remediation - Previous Grade(s) Standard: 8.F.B.4
Algebra I Standard Taught in Advance: 🟩A1: F-IF.A.2
Algebra I Standard Taught Concurrently: none

The average rate of change of a function $y = f(x)$ over an interval $[a, b]$ is $\frac{\Delta y}{\Delta x} = \frac{f(b)-f(a)}{b-a}$

In addition to finding average rates of change from functions given symbolically, graphically, or in a table, students may collect data from experiments or simulations (ex. falling ball, velocity of a car, etc.) and find average rates of change over various intervals.

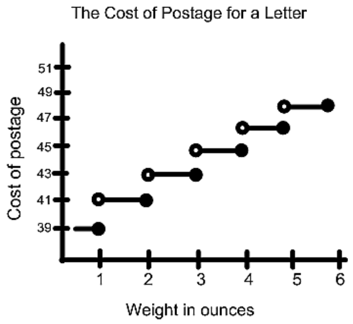
Examples:

- The plug is pulled in a small hot tub. The table gives the volume of water in the tub from the moment the plug is pulled, until it is empty. What is the average rate of change between:
  a. 60 seconds and 100 seconds?
  b. 0 seconds and 120 seconds?
  c. 70 seconds and 110 seconds?

Draining Water from a Hot Tub

Time (s)	Volume (L)
0	1600
10	1344
20	1111
30	900
40	711
50	544
60	400
70	278
80	178
90	100
100	44
110	11
120	0

- Compare the rate of change for the cost of postage for a letter over the interval $1 \le x \le 2$ to the interval $3 \le x \le 6$.



- High School Gym Problem: https://www.illustrativemathematics.org/content-standards/HSF/IF/B/6/tasks/577
- Mathemafish Population: https://www.illustrativemathematics.org/content-standards/HSF/IF/B/6/tasks/686
- Temperature Change: https://www.illustrativemathematics.org/content-standards/HSF/IF/B/6/tasks/1500

Functions: Interpreting Functions (F-IF)

Analyze functions using different representations.

In this cluster, the terms students should learn to use with increasing precision are **linear, piecewise linear, absolute value, quadratic and exponential functions; symbolically expressed functions; factor and complete the square of a quadratic function to show intercepts, maxima,, minima, zeros, symmetry, extreme values.**

Louisiana Standard	Explanations and Examples
🟦**A1: F-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. ★ a. Graph linear and quadratic functions and show intercepts, maxima, and minima. b. Graph piecewise linear (to include absolute value) and exponential functions.	**Component(s) of Rigor:** Conceptual Understanding (7, 7a), Procedural Skill and Fluency (7, 7a, 7b) **Remediation - Previous Grade(s) Standard:** 🟩8.EE.B.5, 🟩8.F.A.3 **Algebra I Standard Taught in Advance:** 🟩A1: F-IF.A.1 **Algebra I Standard Taught Concurrently:** 🟦A1: F-IF.C.8, 🟡A1: F-BF.B.3 Key characteristics include but are not limited to maxima, minima, intercepts, symmetry, end behavior, and asymptotes. Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. **Examples:** • Graph the function $f(x) = \lvert x - 3 \rvert + 5$. Identify the key characteristics of the graph. • Graph and identify the key characteristics of the function described below. $f(x) = \begin{cases} x + 2 \text{ for } x \geq 0 \\ x + 5 \text{ for } x < -1 \end{cases}$ • Graph the function $f(x) = 2^x$ by creating a table of values. Identify the key characteristics of the graph. • Without using the graphing capabilities of a calculator, sketch the graph of $f(x) = x^2 + 7x + 10$ and identify the x-intercepts, y-intercept, and the maximum or minimum point.

🟦**A1: F-IF.C.8** Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.	**Component(s) of Rigor:** Conceptual Understanding (8,8a), Procedural Skill and Fluency (8, 8a) **Remediation - Previous Grade(s) Standard:** 🟩7.EE.A.1 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** 🟦A1: F-IF.C.7 Focus on factoring as a process to show zeroes, extreme values, and symmetry of the graph. Students should be prepared to factor quadratics in which the coefficient of the quadratic term is an integer that may or may not be the GCF of the expression. Students must use the factors to reveal and explain properties of the function, interpreting them in context. **Factoring just to factor does not fully address this standard.** **Example:** • Springboard Dive: https://www.illustrativemathematics.org/content-standards/HSF/IF/C/8/tasks/375

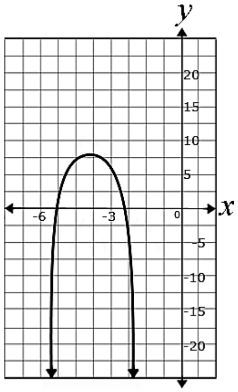
🟦**A1: F-IF.C.9** Compare properties of two functions (linear, quadratic, piecewise linear [to include absolute value] or exponential) each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, determine which has the larger maximum.*

Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency
Remediation - Previous Grade(s) Standard: none
Algebra I Standard Taught in Advance: 🟩A1: F-IF.B.4, 🟦A1: F-IF.C.8
Algebra I Standard Taught Concurrently: none

Examples:

- Examine the functions below. Which function has the larger maximum? How do you know?

$f(x) = -2x^2\text{-}8x + 20$



- Examine the two functions represented below. Compare the x-intercepts and find the difference between the minimum values.

x	-7	-6	-5	-4	-3	-2	-1
$g(x)$	4	1.5	0	-0.5	0	1.5	4

$f(x) = x^2 + 8x + 15$

Functions: Building Functions (F-BF)

Build a function that models a relationship between two quantities.

In this cluster, the terms students should learn to use with increasing precision are **explicit expression, recursive process, function notation, understand the effect of k on $f(x)$ where f(x) is linear, piecewise linear, absolute value, quadratic or an exponential function.**

Louisiana Standard

🟦**A1: F-BF.A.1** Write a linear, quadratic, or exponential function that describes a relationship between two quantities. ★

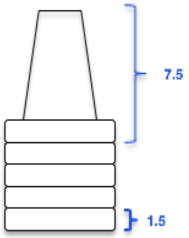
a. Determine an explicit expression, a recursive process, or steps for calculation from a context.

Explanations and Examples

Component(s) of Rigor: Conceptual Understanding (1, 1a), Procedural Skill and Fluency (1, 1a)
Remediation - Previous Grade(s) Standard: 🟦8.F.B.4
Algebra I Standard Taught in Advance: none
Algebra I Standard Taught Concurrently: 🟩A1: F-IF.A.3

Examples:

- The height of a stack of cups is a function of the number of cups in the stack. If a 7.5” cup with a 1.5” lip is stacked vertically, determine a function that would provide you with the height based on any number of cups.



- The price of a new computer decreases with age. Examine the table by analyzing outputs.
  a. Informally describe a recursive relationship. *Note: Determine the average rate at which the computer is decreasing over time.*
  b. Analyze the input and the output pairs to determine an explicit function that represents the value of the computer when the age is known
  .

Computer Age (years)	Value
1	$1575
2	$1200
3	$900
4	$650
5	$500
6	$400
7	$300

- Sidewalk Patterns: http://map.mathshell.org/tasks.php?unit=HA06&collection=9&redir=1
- Skeleton Tower: http://www.illustrativemathematics.org/illustrations/75

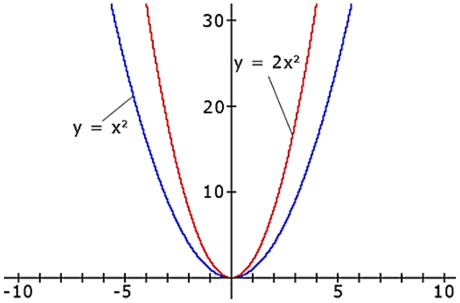
○**A1: F-BF.B.3** Identify the effect on the graph of replacing $f(x)$ by $f(x) + k, kf(x), f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative). Without technology, find the value of k given the graphs of linear and quadratic functions. With technology, experiment with cases and illustrate an explanation of the effects on the graph that include cases where $f(x)$ is a linear, quadratic, piecewise linear (to include absolute value), or exponential function.

Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency
Remediation - Previous Grade(s) Standard: none
Algebra I Standard Taught in Advance: none
Algebra I Standard Taught Concurrently: □A1: F-IF.C.7

Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to graph functions. Although this standard is considered additional work, it should be leveraged to help students see how all of the functions studied in Algebra I behave similarly in terms of transformations on the coordinate plane (a major topic of study in Grade 8).

Examples:

- Compare the shape and position of the graphs of $f(x) = x^2$ and $(x) = 2x^2$, and explain the differences in terms of the algebraic expressions for the functions.



- Describe the effect of varying the parameters *a, h,* and *k* have on the shape and position of the graph of $f(x) = a(x - h)^2 + k$.
- Describe how the graph of $f(x) + k$ compares to $f(x)$ if k positive. If k is negative.

Functions: Linear, Quadratic, and Exponential Models (F-LE)

Construct and compare linear, quadratic, and exponential models and solve problems.

In this cluster, the terms students should learn to use with increasing precision are **equal differences, equal intervals, equal factors, constant rate, growth and decay by a constant rate, construct a function, and increase exponentially, linearly, quadratically.**

Louisiana Standard	Explanations and Examples
🟦**A1: F-LE.A.1** Distinguish between situations that can be modeled with linear functions and with exponential functions. a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. ★	**Component(s) of Rigor:** Conceptual Understanding (1, 1a, 1b, 1c) **Remediation - Previous Grade(s) Standard:** 🟩8.F.A.3, 🟦8.F.B.4 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** none Students may use graphing calculators or programs, spreadsheets, or computer algebra systems to model and compare linear and exponential functions. Students distinguish between a constant rate of change and a constant percent rate of change. **Examples:** • Town A adds 10 people per year to its population, and town B grows by 10% each year. In 2006, each town has 145 residents. For each town, determine whether the population growth is linear or exponential. Explain. • A couple wants to buy a house in five years. They need to save a down payment of $8,000. They deposit $1,000 in a bank account earning 3.25% interest, compounded quarterly. Would the total amount saved for an unknown period of time be modeled better by a linear or exponential function? Explain. • Carbon 14 is a common form of carbon which decays exponentially over time. The half-life of Carbon 14, that is the amount of time it takes for half of any amount of Carbon 14 to decay, is approximately 5730 years. Suppose we have a plant fossil and that the plant, at the time it died, contained 10 micrograms of Carbon 14 (one microgram is equal to one millionth of a gram). Would the total amount of Carbon 14 for an unknown period of time be modeled better by a linear or exponential function? Explain.

<table>
<tr>
<td>A1: F-LE.A.2 Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). ★</td>
<td>
Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency
Remediation - Previous Grade(s) Standard: 8.F.B.4
Algebra I Standard Taught in Advance: A1: F-LE.A.1
Algebra I Standard Taught Concurrently: none
<hr>
Example:

Albuquerque boasts one of the longest aerial trams in the world. The tram transports people up to Sandia Peak. The table shows the elevation of the tram at various times during a particular ride.
<table>
<tr><td>Minutes into the ride</td><td>2</td><td>5</td><td>9</td><td>14</td></tr>
<tr><td>Elevation in feet</td><td>7069</td><td>7834</td><td>8854</td><td>10,129</td></tr>
</table>
Write an equation for a function that models the relationship between the elevation of the tram and the number of minutes into the ride.
After a record setting winter storm, there are 10 inches of snow on the ground! Now that the sun is finally out, the snow is melting. At 7 am there were 10 inches and at 12 pm there were 6 inches of snow.
<ol type="a">
Construct a linear function rule to model the amount of snow.
Construct an exponential function rule to model the amount of snow.
Which model best describes the amount of snow? Provide reasoning for your choice

</td>
</tr>
<tr>
<td>A1: F-LE.A.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function. ★</td>
<td>
Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: none
Algebra I Standard Taught in Advance: A1: F-LE.A.1
Algebra I Standard Taught Concurrently: none
<hr>
Examples:

Compare the values of the functions: $f(x) = 2x$, $f(x) = 2^x$, and $f(x) = x^2$ for $x \geq 0$.
Kevin and Joseph each decide to invest $100. Kevin decides to invest in an account that will earn $5 every month. Joseph decided to invest in an account that will earn 3% interest every month.
<ol type="a">
Whose account will have more money in it after two years?
After how many months will the accounts have the same amount of money in them?
Describe what happens as the money is left in the accounts for longer periods of time.

</td>
</tr>
</table>

Functions: Linear, Quadratic, and Exponential Models (F-LE)

B. Interpret expressions for functions in terms of the situation they model

In this cluster, the terms students should learn to use with increasing precision are **parameters in terms of context.**

Louisiana Standard

□**A1: F-LE.B.5** Interpret the parameters in a linear or exponential function in terms of a context. ★

Explanations and Examples

Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: none
Algebra I Standard Taught in Advance: ○A1: F-BF.B.3, □A1: F-LE.A.2
Algebra I Standard Taught Concurrently: none

Use real-world situations to help students understand how the parameters of linear and exponential functions depend on the context.

Examples:

- The total costs for a plumber who charges \$50 for a house call and \$85 per hour can be expressed as the function $y = 85x + 50$. If the rate were raised to \$90 per hour, how would the function change?

- Lauren keeps records of the distances she travels in a taxi and what it costs:

Distance, *d* (miles)	Fare, *f* (dollars)
3	8.25
5	12.75
11	26.25

  a. If you graph the ordered pairs (d, f) from the table, they lie on a line. How can this be determined without graphing them?
  b. Show that the equation for Part a is $f = 2.25d + 1.5$.
  c. What do the 2.25 and the 1.5 in the equation represent in terms of taxi rides?

- The equation $y = 8{,}000(1.04)^x$ models the rising population of a city with 8,000 residents when the annual growth rate is 4%.
  a. What would be the effect on the equation if the city's population were 12,000 instead of 8,000?
  b. What would happen to the population over 25 years if the growth rate were 6% instead of 4%?

Statistics and Probability: Interpreting Categorical and Quantitative Data★ (S-ID)

Summarize, represent, and interpret data on a single count or measurement variable.

In this cluster, the terms students should learn to use with increasing precision are **data distribution, center, spread, shape, and outliers.**

Louisiana Standard	Explanations and Examples
○**A1: S-ID.A.2** Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. ★	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** ○6.SP.A.2, ○6.SP.B.5 **Algebra I Standard Taught in Advance:** none **Algebra I Standard Taught Concurrently:** ○A1: S-ID.A.3 Given one or more sets of data or two graphs, students: • Identify the similarities and differences in shape, center and spread. • Compare data sets and summarize the similarities and difference between the shape, and measures of center and spreads of the data sets. • Use the correct measure of center and spread to describe a distribution that is symmetric or skewed. • Identify outliers and their effects on data sets. The mean and standard deviation are most commonly used to describe sets of data. However, if the distribution is extremely skewed and/or has outliers, it is best to use the median and the interquartile range to describe the distribution since these measures are not sensitive to outliers. **Examples:** • Haircut Costs: https://www.illustrativemathematics.org/content-standards/HSS/ID/A/2/tasks/942 • Speed Trap: https://www.illustrativemathematics.org/content-standards/HSS/ID/A/2/tasks/1027

○**A1: S-ID.A.2** *continued*

- Delia wanted to find the best type of fertilizer for her tomato plants. She purchased three types of fertilizer and used each on a set of seedlings. After 10 days, she measured the heights (cm) of each set of seedlings. The data she collected is shown on the next page
    a. Construct box plots to analyze the data.
    b. Write a brief description comparing the three types of fertilizer.
    c. Which fertilizer do you recommend that Delia use? Explain your answer.

Fertilizer A		
7.1	6.3	1.0
5.0	4.5	5.2
3.2	4.6	2.4
5.5	3.8	1.5
6.2	6.9	2.6

Fertilizer B		
11.0	9.2	5.6
8.4	7.2	12.1
10.5	14.0	15.3
6.3	8.7	11.3
17.0	13.5	14.2

Fertilizer C		
10.5	11.8	15.5
14.7	11.0	10.8
13.9	12.7	9.9
10.3	10.1	15.8
9.5	13.2	9.7

A1: S-ID.A.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). ★

Component(s) of Rigor: Conceptual Understanding
Remediation - Previous Grade(s) Standard: 6.SP.B.5
Algebra I Standard Taught in Advance: none
Algebra I Standard Taught Concurrently: A1: S-ID.A.2

Students understand and use the context of the data to explain why its distribution takes on a particular shape (e.g. is the data skewed? are there outliers?)

Examples:

- Why does the shape of the distribution of incomes for professional athletes tend to be skewed to the right?
- Why does the shape of the distribution of test scores on a really easy test tend to be skewed to the left?
- Why does the shape of the distribution of heights of the students at your school tend to be symmetrical?

Students understand that the higher the value of a measure of variability, the more spread out the data set is. Measures of variability are range (100% of data), standard deviation (68-95-99.7% of data), and interquartile range (50% of data).

Example:

- On last week’s math test, Mrs. Smith’s class had an average of 83 points with a standard deviation of 8 points. Mr. Tucker’s class had an average of 78 points with a standard deviation of 4 points. Which class was more consistent with their test scores? How do you know?

Students explain the effect of any outliers on the shape, center, and spread of the data sets.

Example:

The heights of a group of women basketball players are: 5 ft. 9 in., 5 ft. 4 in., 5 ft. 7 in., 5 ft. 6 in., 5 ft. 5 in., 5 ft. 3 in., and 5 ft. 7 in. A new player joins the basketball team. Her height is 6 ft. 10 in.

a. What is the mean height of the team before the new player transfers in? What is the median height?
b. What is the mean height after the new player transfers? What is the median height?
c. What affect does her height have on the team’s height distribution and stats (center and spread)?
d. How many players are taller than the new mean team height?
e. Which measure of center most accurately describes the team’s average height? Explain.

Statistics and Probability: Interpreting Categorical and Quantitative Data ★(S-ID)

Summarize, represent, and interpret data on two categorical and quantitative variables.

In this cluster, the terms students should learn to use with increasing precision are **categorical data, two-way frequency tables, relative frequencies, trends in data, scatter plot, fit a function to data, and residuals.**

Louisiana Standard

A1: S-ID.B.5 Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.★

Explanations and Examples

Component(s) of Rigor: Conceptual Understanding, Procedural Skill and Fluency

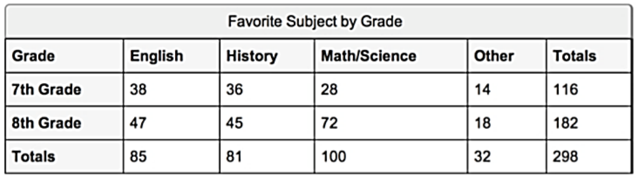
Remediation - Previous Grade(s) Standard: 8.SP.A.4

Algebra I Standard Taught in Advance: none

Algebra I Standard Taught Concurrently: none

When students are proficient with analyzing two-way frequency tables, build upon their understanding to develop the vocabulary.

- The table entries are the joint frequencies of how many subjects displayed the respective cross-classified values.
- Row totals and column totals constitute the marginal frequencies.
- Dividing joint or marginal frequencies by the total number of subjects define relative frequencies, respectively.



Favorite Subject by Grade

Grade	English	History	Math/Science	Other	Totals
7th Grade	38	36	28	14	116
8th Grade	47	45	72	18	182
Totals	85	81	100	32	298

Conditional relative frequencies are determined by focusing on a specific row or column of the table and are particularly useful in determining any associations between the two variables.

Students are flexible in identifying and interpreting the information from a two-way frequency table. They complete calculations to determine frequencies and use those frequencies to describe and compare.

Example:

- At the NC Zoo, 23 interns were asked their preference of where they would like to work. There were three choices: African Region, Aviary, or North American Region. There were 13 who preferred the African Region, 5 of them were male. There were 6 who preferred the Aviary, 2 males and 4 females. A total of 4 preferred the North American Region and only 1 of them was female.
  a. Using the information on the NC Zoo Internship to create a two way frequency table.
  b. Using the two-way frequency table from the NC Zoo Internship, calculate:
     i. the percentage of males who prefer the African Region
  c. How does the percentage of males who prefer the African Region compare to the percentage of females who prefer the African Region?
  d. 15% of the paid employees are male and work in the Aviary. How does that compare to the interns who are male and prefer to work in the Aviary? Explain how you made your comparison.

A1: S-ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. ★

a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear and quadratic models.*

b. Informally assess the fit of a function by plotting and analyzing residuals.

c. Fit a linear function for a scatter plot that suggests a linear association.

Component(s) of Rigor: Conceptual Understanding (6, 6a, 6b), Procedural Skill and Fluency (6, 6a, 6b, 6c), Application (6a)
Remediation - Previous Grade(s) Standard: 8.SP.A.1, 8.SP.A.2, 8.SP.A.3
Algebra I Standard Taught in Advance: none
Algebra I Standard Taught Concurrently: none

Year (0=1990)	Tuition Rate
0	6546
1	6996
2	6996
3	7350
4	7500
5	7978
6	8377
7	8710
8	9110
9	9411
10	9800

A ***residual*** is the difference between the actual y-value and the predicted y-value $(y - \hat{y})$, which is a measure of the error in prediction. (Note: $\hat{y}$ is the symbol for the predicted y-value for a given *x*-value.) A residual is represented on the graph of the data by the vertical distance between a data point and the graph of the function.

A ***residual plot*** is a graph that shows the residuals on the vertical axis and the independent variable on the horizontal axis. If the points in a residual plot are randomly dispersed around the horizontal axis, a linear regression model is appropriate for the data; otherwise, a non-linear model is more appropriate.

Example:

The table to the left displays the annual tuition rates of a state college in the U.S. between 1990 and 2000, inclusively. The linear function $R(t) = 326x + 6440$ has been suggested as a good fit for the data. Use a residual plot to determine the goodness of fit of the function for the data provided in the table.

Examples:

- The data in the chart give number of miles driven and advertised price for 11 used models of a particular car from 2002 to 2006.
    a. Use your calculator to make a scatter plot of the data.
    b. Use your calculator to find the correlation coefficient for the data above. Describe what the correlation means in regards to the data.
    c. Use your calculator to find an appropriate linear function to model the relationship between miles driven and price for these cars.
    d. How do you know that this is the best-fit model?

Miles driven (In thousands)	Price (In dollars)
22	17,998
29	16,450
35	14,998
39	13,998
45	14,599
49	14,988
55	13,599
56	14,599
69	11,998
70	14,450
86	10,998

☐**A1: S-ID.B.6** *continued*

Students fit a quadratic function for a scatter plot that suggests a quadratic association.

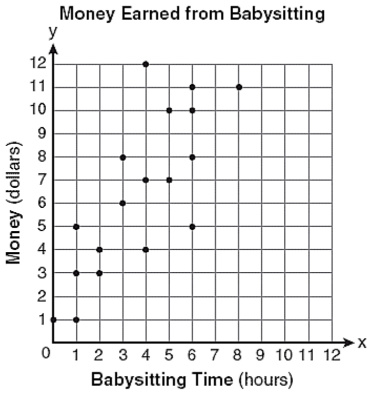
- A study was done to compare the speed x (in miles per hour) with the mileage y (in miles per gallon) of an automobile. The results are shown in the table.
  (Source: Federal Highway Administration)
  a. Use your calculator to make a scatter plot of the data.
  b. Use the regression feature to find a model that best fits the data.
  c. Approximate the speed at which the mileage is the greatest.

Speed, x (mph)	**Mileage, y (mpg)**
15	22.3
20	25.5
25	27.5
30	29.0
35	28.8
40	30.0
45	29.9
50	30.2
55	30.4
60	28.8
65	27.4
70	25.3
75	23.3

Students fit a linear function for a scatter plot that suggests a linear association.

- Which of the following equations best models the (babysitting time, money earned) data?

  $y = x$ $\qquad y = \frac{6}{5}x + 2$ $\qquad y = \frac{3}{2}x + 4$ $\qquad y = \frac{1}{4}x + 4$



Statistics and Probability: Interpreting Categorical and Quantitative Data ★(S-ID)

Interpret linear models.

In this cluster, the terms students should learn to use with increasing precision are **rate of change, intercept, correlation coefficient of a linear fit, and correlation versus causation.**

Louisiana Standard	**Explanations and Examples**
🟩**A1: S-ID.C.7** Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. ★	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** ◻8.SP.A.3 **Algebra I Standard Taught in Advance:** ◻A1: S-ID.B.6 **Algebra I Standard Taught Concurrently:** none Students may use graphing calculators or software to create representations of data sets, create linear models, and to assist student them in interpreting the data. **Example:** • Data were collected of the weight of a male white laboratory rat for the first 25 weeks after its birth. A scatterplot of the rat's weight (in grams) and the time since birth (in weeks) shows a fairly strong, positive linear relationship. The linear regression equation $W = 100 + 40t$ (where *W* = weight in grams and *t* = number of weeks since birth) models the data fairly well. a. What is the slope of the linear regression equation? Explain what it means in context. b. What is the *y*-intercept of the linear regression equation? Explain what it means in context.
🟩**A1: S-ID.C.8** Compute (using technology) and interpret the correlation coefficient of a linear fit. ★	**Component(s) of Rigor:** Conceptual Understanding, Procedural Skill and Fluency **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** ◻A1: S-ID.B.6 **Algebra I Standard Taught Concurrently:** 🟩A1: S-ID.C.9 Students may use graphing calculators or software to create representations of data sets and create linear models and interpret them. The correlation coefficient, *r*, is a measure of the strength and direction of a linear relationship between two quantities in a set of data. The magnitude (absolute value) of *r* indicates how closely the data points fit a linear pattern. If $r = 1$, the points all fall on a line. The closer $\|r\|$ is to 1, the stronger the correlation. The closer $\|r\|$ is to zero, the weaker the correlation. The sign of *r* indicates the direction of the relationship, positive or negative. **Example:** • Coffee and Crime: https://www.illustrativemathematics.org/content-standards/HSS/ID/C/8/tasks/1307

🟩**A1: S-ID.C.9** Distinguish between correlation and causation. ★	**Component(s) of Rigor:** Conceptual Understanding **Remediation - Previous Grade(s) Standard:** none **Algebra I Standard Taught in Advance:** 🟦A1: S-ID.B.6 **Algebra I Standard Taught Concurrently:** 🟩A1: S-ID.C.8 Some data lead observers to believe that there is a cause and effect relationship when a strong relationship is observed. Students should be careful not to assume that correlation implies causation. The determination that one thing causes another requires a controlled randomized experiment. **Examples:** • A study found a strong, positive correlation between the number of cars owned and the length of one's life. Larry concludes that owning more cars means you will live longer. Does this seem reasonable? Explain your answer. • High blood pressure: https://www.illustrativemathematics.org/content-standards/HSS/ID/C/9/tasks/1100 • Math test grades: https://www.illustrativemathematics.org/content-standards/HSS/ID/C/9/tasks/1585

Grade 6 Standards

🟩**6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

a. Make tables of equivalent ratios relating quantities with whole-number measurements, find missing values in the tables, and plot the pairs of values on the coordinate plane. Use tables to compare ratios.
b. Solve unit rate problems including those involving unit pricing and constant speed. *For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what unit rate were lawns being mowed?*
c. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.
d. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Return to 🟦A1: N-Q.A.1

🟩**6.EE.A.2** Write, read, and evaluate expressions in which letters stand for numbers.

a. Write expressions that record operations with numbers and with letters standing for numbers. *For example, express the calculation "Subtract y from 5" as 5 - y.*
b. Identify parts of an expression using mathematical terms (sum, term, product, factor, quotient, coefficient); view one or more parts of an expression as a single entity. *For example, describe the expression 2 (8 + 7) as a product of two factors; view (8 + 7) as both a single entity and a sum of two terms.*
c. Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations). *For example, use the formulas* $V = s^3$ *and* $A = 6\ s^2$ *to find the volume and surface area of a cube with sides of length s = 1/2.*

Return to 🟩 A1: A-SSE.A.1, 🟩 A1: F-IF.A.2

🟩**6.EE.A.3** Apply the properties of operations to generate equivalent expressions. *For example, apply the distributive property to the expression 3 (2 + x) to produce the equivalent expression 6 + 3x; apply the distributive property to the expression 24x + 18y to produce the equivalent expression 6 (4x + 3y); apply properties of operations to y + y + y to produce the equivalent expression 3y*. *Return to* 🟩A1: A-SSE.A.2, 🟦A1: A-SSE.B.3, 🟩A1: A-APR.A.1

🟩**6.EE.A.4** Identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them). *For example, the expressions y + y + y and 3y are equivalent because they name the same number regardless of which number y stands for.*

Return to 🟩A1: A-APR.A.1

○**6.SP.A.2** Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

Return to ○A1: S-ID.A.2

○**6.SP.B.5** Summarize numerical data sets in relation to their context, such as by:

a. Reporting the number of observations.
b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
d. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.

Return to ○ A1: S-ID.A.2, ○ A1: S-ID.A.3

Grade 7 Standards

🟩**7.EE.A.1** Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients to include multiple grouping symbols (e.g., parentheses, brackets, and braces). *Return to* 🟩A1: A-SSE.A.2, ▣A1: A-SSE.B.3, 🟩A1: A-APR.A.1, ▣A1: A-APR.B.3, 🟩A1: A-REI.B.4, ▣A1: F-IF.C.8

🟩**7.EE.A.2** Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related. *For example, a + 0.05a = 1.05a means that "increase by 5%" is the same as "multiply by 1.05."* *Return to* 🟩A1: A-SSE.A.1

🟩**7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

a. Solve word problems leading to equations of the form $px + q = r$ and $p(x + q) = r$, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach. *For example, the perimeter of a rectangle is 54 cm. Its length is 6 cm. What is its width?*
b. Solve word problems leading to inequalities of the form $px + q > r$, $px + q \geq r$, $px + q < r$ or $px + q \leq r$, where p, q, and r are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem. *For example: As a salesperson, you are paid $50 per week plus $3 per sale. This week you want your pay to be at least $100. Write an inequality for the number of sales you need to make, and describe the solutions.*

Return to 🟩A1: A-CED.A.1, 🟩A1: A-REI.A.1, 🟩A1: A-REI.B.3

Grade 8 Standards

▣**8.NS.A.1** Know that numbers that are not rational are called irrational. Understand informally that every number has a decimal expansion; for rational numbers show that the decimal expansion repeats eventually. Convert a decimal expansion which repeats eventually into a rational number by analyzing repeating patterns. *Return to* ○A1: N-RN.B.3

🟩**8.EE.A.1** Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example, $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$.

Return to ▣A1: A-SSE.B.3, 🟩 A1: A-APR.A.1

🟩**8.EE.A.2** Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational. *Return to* 🟩A1: A-REI.B.4

🟩**8.EE.A.4** Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. *Return to* ▣A1: N-Q.A.3

🟩**8.EE.B.5** Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.
Return to ▣A1: A-REI.D.10, ▣A1: F-IF-C.7

🟩**8.EE.C.7** Solve linear equations in one variable.

a. Give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions. 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).

b. Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.

Return to 🟩A1: A-CED.A.1, 🟩A1: A-REI.A.1, 🟩A1: A-REI.B.3

🟩**8.EE.C.8** Analyze and solve pairs of simultaneous linear equations.

a. Understand that solutions to a system of two linear equations in two variables correspond to points of intersection of their graphs, because points of intersection satisfy both equations simultaneously.

b. Solve systems of two linear equations in two variables algebraically, and estimate solutions by graphing the equations. Solve simple cases by inspection. *For example, $3x + 2y = 5$ and $3x + 2y = 6$ have no solution because $3x + 2y$ cannot simultaneously be 5 and 6*.

c. Solve real-world and mathematical problems leading to two linear equations in two variables. *For example, given coordinates for two pairs of points, determine whether the line through the first pair of points intersects the line through the second pair*.

Return to 🟩A1: A-CED.A.2, ○A1: A-REI.C.5, ○A1: A-RECI.C.6, 🟩A1: A-REI.D.11

🟩**8.F.A.1** Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output. (Function notation is not required in this grade level.) *Return to* 🟩A1: F-IF.A.1

🟩**8.F.A.2** Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For 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*. *Return to* 🟩A1: F-IF.A.1

🟩**8.F.A.3** Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; categorize functions as linear or nonlinear when given equations, graphs, or tables. *For example, 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*. *Return to* 🟩A1: A-CED.A.2, 🟩A1: F-IF.A.1, ▣A1: F-IF.C.7, ▣A1: F-LE.A.1

🟦**8.F.B.4** 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. Interpret 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. *Return to* 🟩A1: A-CED.A.2, 🟩A1: F-IF.B.6, 🟦A1: F-BF.A.1, 🟦A1: F-LE.A.1, 🟦A1: F-LE.A.2

🟦**8.F.B.5** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. *Return to* 🟩A1: F-IF.B.4

🟦**8.SP.A.1** Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association. *Return to* 🟦A1: S-ID.B.6

🟦**8.SP.A.2** Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line. *Return to* 🟦A1: S-ID.B.6

🟦**8.SP.A.3** Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept. *For 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*. *Return to* 🟦A1: S-ID.B.6, 🟩A1: S-ID.C.7

🟦**8.SP.A.4** Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables. *For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores? Return to* 🟦A1: S-ID.B.5