Pre-AP®
Algebra 1

COURSE GUIDE
Includes the Course Framework
Pre-AP® Algebra 1 Course Guide
Fall 2018

Please visit Pre-AP online (pre-ap.collegeboard.org) for more information about the course launch and program features.
About the College Board

The College Board is a mission-driven not-for-profit organization that connects students to college success and opportunity. Founded in 1900, the College Board was created to expand access to higher education. Today, the membership association is made up of over 6,000 of the world’s leading educational institutions and is dedicated to promoting excellence and equity in education. Each year, the College Board helps more than seven million students prepare for a successful transition to college through programs and services in college readiness and college success—including the SAT® and the Advanced Placement Program®. The organization also serves the education community through research and advocacy on behalf of students, educators, and schools.

For further information, visit www.collegeboard.org.
"Begin with the end in mind," Stephen Covey advised in his widely read 7 Habits of Highly Effective People. He explained that forming a mental vision of our destination (in life or career) is what allows our own decisions and actions, not others’, to guide us there. "Beginning with the end in mind" is also the underlying principle of Understanding by Design™, a widely used framework developed by Grant Wiggins and Jay McTighe that describes how curriculum and instructional design should be driven by the eventual outcomes we want for students. Two seminal works—one in the areas of business and self-help, one in the field of education—advance this singular principle that makes perfect sense. For ninth-grade students, this idea that connects both to how we live and how we learn carries particular resonance.

The beginning of high school is a daunting time for many students. Many do not yet have a clear vision for where they want to end up, academically or career-wise. Most want to go to some sort of college, but they depend on the adults in their lives—teachers, parents, family members—to guide them on how to get there and how to make the right choices along the way. For the most talented and motivated students, the ones whose families have navigated themselves to their college and career aspirations, this process can be smooth, even if the work itself is challenging. But most students need much more guidance and support, especially when it comes to developing the knowledge, skills, and habits of mind that will allow them to succeed in college. With postsecondary education increasingly a “must” for earning a good wage and having a rewarding career, getting all students college ready is a responsibility that falls heavily upon high school teachers and administrators.

If college is the end, then let’s help our students have a vision of what that looks like in their minds from the moment they start ninth grade. How do successful college (and AP) students read for details and evidence, whether they are reading a piece of literature, a history textbook, or a technical manual? How do they craft sentences and paragraphs to compellingly make claims supported with solid evidence? How do they interpret and use data from charts and maps? How do they make sense of the world and solve problems using quantitative information? When students know what will be expected down the road, and have opportunities to practice with grade-appropriate content and contexts, with ample support and feedback from teachers across different subjects, there are fewer surprises and unknowns. The process is more transparent and fair, giving more students the opportunity to succeed.

The College Board has followed this principle of "beginning with the end in mind" in designing this program. All students will leave high school ready for college and career—this is the vision shared by our members, our leadership, our staff, and all of you, the schools joining with us as we launch the Pre-AP Program. We are honored by your participation and look forward to our partnership in the years to come.

Auditi Chakravarty, Vice President
SpringBoard and Pre-AP Programs
Acknowledgments

The College Board would like to acknowledge the following committee members, consultants, and reviewers for their assistance with and commitment to the development of this course. All individuals and their affiliations were current at the time of contribution.

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About Pre-AP

Pre-AP provides teachers and students with instructional resources, classroom-based assessments, high-quality professional learning, and meaningful student practice in five new ninth-grade courses. Participating schools receive an official Pre-AP designation for each course and the chance to bring engaging, meaningful coursework to all their students. This designation signals consistent, high standards in focused courses that help build, strengthen, and reinforce students’ content knowledge and skills. Pre-AP courses will get students ready for college-level coursework, including AP courses and exams. And they’ll be open to all.

The Pre-AP program’s objectives are to:

- Significantly increase the number of students who are able to access and complete college-level work—like AP—before leaving high school; and
- Improve the college readiness of all students.

Each Pre-AP course has been developed by committees of expert educators, including middle school, high school, and college faculty. These development committees work with the College Board to design effective frameworks and instructional resources that emphasize and prioritize the content and skills that matter most for later high school coursework and college and career readiness. In addition, assessments and performance tasks situated throughout the year provide regular, actionable feedback. We believe that students and teachers have the right to know how they’re progressing—in real time.

Participation in Pre-AP courses places students on a path to college readiness. These courses provide students with opportunities to engage deeply with texts, motivating problems to solve and questions to answer, and key concepts that focus on the content and skills central to each discipline. Across the ninth-grade Pre-AP courses, students will experience shared classroom routines that foster and deepen college-readiness skills. Finally, students will take classroom assessments that provide meaningful and actionable feedback on college-readiness indicators.
Theory of Action

Pre-AP is designed to both facilitate and measure student learning while supporting teacher practice in the orchestration of instruction and assessment in the classroom. The Pre-AP theory of action is threefold: 1) purposeful and focused content, 2) horizontal alignment of skills and strategies, and 3) targeted assessments tied with feedback. These elements guide Pre-AP curriculum and assessment design in order to support teacher learning as a means to increase student success. Therefore, these design features should widen the net of the number of students prepared for later high school and college coursework.

Design Features and Intended Effects

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Description and Intended Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focused content</td>
<td>Pre-AP frameworks provide a deep focus on a limited number of concepts and skills that have broadest relevance for high school coursework and college success. Course frameworks are back mapped from AP expectations and aligned to grade-level-appropriate SAT content dimensions. The resulting focused course content allows more time for students to develop, practice, and master skills and concepts, thus building more durable knowledge and skills to use throughout their high school and college coursework.</td>
</tr>
<tr>
<td>Horizontal alignment</td>
<td>Each Pre-AP course focuses on three areas of focus that are central to the discipline and that emphasize the role of literacy, quantitative, and/or analytical skills that enable students to transfer knowledge within and across courses. All five Pre-AP disciplines also share a common set of shared principles, or routines, that guide classroom practice and undergird the Pre-AP instructional units. These routines further strengthen students’ reading, analysis, writing, problem-solving, and communication skills. Through engaging in these routines, students gain regular practice at close observation and analysis, evidence-based writing, higher-order questioning, and academic conversation to ultimately equip them to be better prepared for high school and college-level work. Finally, schools that implement multiple Pre-AP courses provide students with the multiplicative effects of cross-disciplinary alignment during the critical early high school years.</td>
</tr>
</tbody>
</table>
### Design Features

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<th>Targeted assessments and feedback</th>
<th>Description and Intended Effects</th>
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<tr>
<td>Reflected in: unit assessments and score reports, performance tasks, teacher professional learning, and online calibration tools for scoring student work</td>
<td>Unit-based assessments, both objective and performance based, provide consistent measurements of student achievement across the course. Pre-AP course teachers receive professional learning and online calibration tools to support the scoring of student work and how to use this feedback to guide student learning. The targeted assessments, feedback reports, and scoring guidelines help build a more consistent teacher understanding of performance expectations required by Pre-AP to build readiness for AP and college-level work. The emphasis on scoring student work and utilizing assessment feedback reports aligns strongly with qualitative feedback from the AP Program on the highly instructive value AP Readings and other distributive scoring models have on teacher understanding of assessment performance benchmarks.</td>
</tr>
</tbody>
</table>

### Additional Resources

Visit [pre-ap.collegeboard.org](http://pre-ap.collegeboard.org) for more information about the Pre-AP Program.
Shared Principles

All Pre-AP courses share a common set of classroom routines and approaches that give students many opportunities to practice and strengthen their skills while building their confidence in the classroom.

**Close Observation and Analysis**
...to notice and consider

In Pre-AP courses, students begin by carefully examining one object, text, performance piece, or problem. They will engage in deep observation to build, refine, or confirm their knowledge, thus developing a foundational skill that supports analysis and learning in each discipline. As students encounter texts, art, graphs, maps, problems, and other source materials, they will learn to first engage in deep, close observation before being asked to explain and then apply or evaluate.

**Evidence-Based Writing**
...with a focus on the sentence

Pre-AP courses value and build time for evidence-based writing in a multitude of forms and for various purposes across the disciplines: crafting claims in science, analyzing sources in history, providing explanations for problems in math, demonstrating reading comprehension in English, and critiquing artistic choices in the arts. Pre-AP courses embrace a purposeful and scaffolded approach to writing that begins with a focus on the sentence before progressing to paragraph- and essay-level writing. All courses embed tools and supports (sentence frames, outlines, and graphic organizers) to strengthen writing skills. In Algebra 1, students will regularly engage in crafting sentence-level written justifications to support or critique mathematical solutions.

**Higher-Order Questioning**
...to spark productive lingering

When examining texts, data, problems, and other sources of evidence, students will grapple with questions that spark curiosity, cultivate wonder, and promote productive lingering. Pre-AP lessons provide teachers with questions that motivate thought and support students as they develop evidence-based claims and solve problems from multiple angles.

**Academic Conversations**
...to support peer-to-peer dialogue

In Pre-AP classrooms, students will have frequent opportunities for active, thoughtful participation in collaborative conversations about significant course themes, topics, texts, and problems. Through these discussions, students will practice the skills of academic conversation that they will need to employ in college and career settings. Students will regularly compare, critique, debate, and build upon others' ideas and arguments to advance their learning.
About the Pre-AP Algebra 1 Course

Pre-AP Algebra 1 focuses deeply on the concepts and skills that have maximum value for college and career. Therefore, a major focus of this course is on mastery of linear relationships. Linear equations and functions represent the most useful and versatile tools in the mathematician’s toolbox, and they are the basic building blocks of many advanced topics in mathematics. Pre-AP Algebra 1 course content is streamlined, allowing time and space to truly master these necessary concepts and skills.

This course creates a platform for all students to build their mathematical muscle and confidence by emphasizing these essential practices for deep mathematical learning:

- Developing conceptual understanding
- Building procedural fluency
- Making and using mathematical models
- Crafting mathematical arguments

Pre-AP Algebra 1 asks students to actively construct mathematical knowledge alongside their peers by productively lingering on problems, persevering through challenges, and making important connections among related concepts. Students will engage in authentic and useful applications of mathematics as they solve real-world problems. Finally, since crafting a mathematical argument lies at the heart of the discipline, students will gain the tools for making, testing, refuting, and supporting mathematical arguments.
Pre-AP Curricular and Resource Requirements

Schools and teachers wishing to offer Pre-AP courses must align their instructional plans to the specific curricular and resource requirements for each course. These requirements have been developed in horizontal alignment across all Pre-AP courses and represent the most essential elements and requirements that support the theory of action and successful Pre-AP student outcomes.

Pre-AP Algebra 1 teachers should use the requirements outlined below, in conjunction with the Pre-AP supplied instructional materials, for their instructional planning.

Pre-AP Algebra 1 Curricular Requirements

Course and Instruction

- The course provides opportunities for students to develop the knowledge and skills articulated in the course framework through student-centered exploration and argumentation.
- The course provides opportunities for students to engage in the three Pre-AP Algebra 1 areas of focus outside of the Pre-AP instructional materials.
  - Mastery of Linear Equations and Linear Functions
  - Greater Authenticity of Applications and Modeling
  - Engagement in Mathematical Argumentation
- The course provides opportunities for students to engage in the Pre-AP shared principles.
  - Close Observation and Analysis
  - Evidence-Based Writing
  - Higher-Order Questioning
  - Academic Conversation
- The course provides time and opportunity to strengthen procedural fluency with the algebraic skills emphasized in the instructional materials throughout the course.

Practice

- The instructional plan for the course includes opportunities for students to continue to practice and develop disciplinary skills outside of the Pre-AP instructional materials within each unit.
Assessment

- The instructional plan for the course includes one performance task and two digital quizzes within each unit.
- The instructional plan reflects time and methods for using the performance task scoring guidelines and score reports for digital quizzes to provide actionable feedback to students.
- The instructional plan reflects time, methods, and strategies for making responsive adjustments to future instruction based on student performance.

Resource Requirements

- The school ensures that Pre-AP coursework is available to all students. This means that the school must not establish any barriers (e.g., test scores, grades in prior coursework, teacher or counselor recommendation) to student participation.
- The school ensures that participating teachers and students are provided with computer and internet access for completion of course and assessment requirements.
- Teachers should have consistent access to a video projector for sharing web-based instructional content and short web videos.
- The school ensures that all teachers and students have access to a graphing utility, such as a graphing calculator or online graphing resource.
Overview

The Algebra 1 course is designed to deepen students' understanding of three big ideas: how the structure of the real number system leads to the rules of algebraic manipulation, how to use functions as a tool for modeling the world, and what information the solution(s) to a mathematical model can and cannot tell you. The Pre-AP Algebra 1 course framework provides a clear and focused description of what students should know and be able to do as a result of this course. The framework increases clarity and provides transparency to both teachers and students about the most essential knowledge and skills students will need for active, confident participation in subsequent high school courses, including Advanced Placement, as well as college coursework and postsecondary careers.

The Pre-AP frameworks are designed using a collaborative and research-based process with a team of master teachers and college faculty. All Pre-AP frameworks are back mapped from Advanced Placement expectations and aligned to grade-level-appropriate content dimensions from the SAT system of assessments. The frameworks are also deeply informed by state standards documents and carefully reviewed by educators. As a guide for classroom instruction and assessment, the course framework serves as the teacher's blueprint for the instructional resources and assessments that are part of the Pre-AP course.

The following design principles shaped the framework development process:

- **Focused**: The framework provides a deep focus on a limited number of concepts and skills that have the broadest relevance for later high school and college success.

- **Collaborative**: The framework is developed through the collaborative expertise of disciplinary experts and cognitive scientists and the pedagogical content knowledge of master teachers.

- **Measurable**: The framework's learning objectives are observable and measurable statements about the content and skills students should develop to be prepared for later high school coursework, and ultimately, college readiness and success.

- **Manageable**: The framework must be manageable for a full year of instruction, foster the ability to explore concepts in depth, and enable room for additional local or state standards to be addressed where appropriate.

- **Accessible**: The framework's learning objectives are designed for all students and represent the foundational concepts and skills all students should have the opportunity to learn to be ready for the widest range of college and postsecondary opportunities.
The Pre-AP Algebra 1 Course Framework is organized around four core units of study:

- **Unit 1: Linear Equations and Linear Functions**
- **Unit 2: Systems of Linear Equations and Inequalities**
- **Unit 3: Quadratic Functions**
- **Unit 4: Exponent Properties and Exponential Functions**

The framework includes the following components:

- **Enduring Understandings**: Each unit focuses on a small set of enduring understandings. These are the long-term, transferable takeaways that students should develop after exploring the concepts and skills related to a given big idea. These understandings are expressed as generalizations that specify what a student will come to understand about the key concepts in this course.

- **Key Concepts**: To support teacher planning and instruction, each core unit is organized by key concepts. The associated learning objectives and essential knowledge for each key concept give clear guidance on what students should know and be able to do in order to master that concept.
  - **Learning Objectives**: These objectives convey what a student needs to be able to do in order to develop the enduring understandings. The learning objectives serve as targets for the development of classroom-based tasks and assessments.
  - **Essential Knowledge**: Essential knowledge statements are linked to specific learning objectives and correspond to the enduring understandings. These statements describe the essential concepts and facts that students need to know in order to demonstrate mastery of each learning objective.

- **Content Boundaries and Cross Connections**: For some key concepts, content boundary and procedural fluency statements are provided to increase clarity and guidance on the content and skills that matter most for subsequent courses. This area also highlights important connections that should be made between key concepts from within and across the units.

## Overview of Pre-AP Algebra 1 Units and Enduring Understandings

<table>
<thead>
<tr>
<th>Unit 1: Linear Equations and Linear Functions</th>
<th>Unit 2: Systems of Linear Equations and Inequalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functions describe a relationship between two variable quantities where one quantity uniquely determines the other.</td>
<td>Solving an equation or inequality is a process of determining the value or values that make the equation or inequality true.</td>
</tr>
<tr>
<td>Functions can be presented algebraically, graphically, in a table of values, or by a verbal description.</td>
<td>Algebraic manipulations can be used to transform algebraic equations and inequalities into equivalent equations and inequalities to reveal various aspects of the relationships present.</td>
</tr>
<tr>
<td>Linear relationships have a constant rate of change.</td>
<td>Solutions to a system of equations or a system of inequalities simultaneously satisfy every equation or inequality in the system.</td>
</tr>
<tr>
<td>Linear functions are useful for analyzing linear contextual situations and for making sense of some nonlinear situations.</td>
<td>Systems of linear equations or inequalities are useful for modeling scenarios that involve resource limitations, goals, constraints, comparisons, and tolerances.</td>
</tr>
<tr>
<td>Solutions to equations and inequalities arising from contextual scenarios have meaning about the real-world situations from which they were modeled.</td>
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</tr>
</tbody>
</table>

### Unit 3: Quadratic Functions

A quadratic function is a function that is defined by a product of two linear expressions.

Quadratic functions have a linear rate of change.

The graph of a quadratic function is symmetric with respect to the vertical line containing its maximum or minimum.

Every quadratic equation, $ax^2 + bx + c = 0$ where $a$ is not zero, can be solved with the quadratic formula, but those solutions may not be real numbers.

### Unit 4: Exponent Properties and Exponential Functions

The set of real numbers can be divided into rational numbers (numbers with terminating or repeating decimal presentations) and irrational numbers (numbers with nonterminating and nonrepeating decimal presentations).

Exponent properties are derived from the properties of multiplication and division.

Exponential functions can be used to model physical scenarios that involve constant multiplicative growth or decay.
Unit 1: Linear Equations and Linear Functions

Suggested Pacing: 9 weeks

Unit Overview

Linear relationships are among the most prevalent and useful relationships in mathematics and the real world. Any equality in two variables that exhibits a constant rate of change for these variables is linear. Real-world contexts that have a constant rate of change and data sets with a nearly constant rate of change can be effectively modeled by a linear function. Students will explore all aspects of linear relationships in this unit: contextual problems that involve constant rate of change, lines in the coordinate plane, arithmetic sequences, and algebraic means of expressing a linear relationship between two quantities. Through this unit, students will develop deep skills with linear functions and equations and develop an appreciation for the simplicity and power of linear functions as building blocks of all higher mathematics.

Unit 1 Enduring Understandings

Students will understand that ...

- Functions describe a relationship between two variable quantities where one quantity uniquely determines the other.
- Functions can be presented algebraically, graphically, in a table of values, or by a verbal description.
- Linear relationships have a constant rate of change.
- Linear functions are useful for analyzing linear contextual situations and for making sense of some nonlinear situations.
- Solutions to equations and inequalities arising from contextual scenarios have meaning about the real-world situations from which they were modeled.

Unit 1 Key Concepts

- Direct Variation
- Slope and Rate of Change
- Linear Functions
- Linear Equations
- Scatterplots and Lines of Fit
- Linear Inequalities
## Key Concept: Direct Variation

### Learning Objectives
*Students will be able to ...*

1.1 Use letters or other symbols to represent variables and parameters.

### Essential Knowledge
*Students need to know that ...*

1.1a A variable is an input or output on which the value of a function or equation depends.

1.1b A parameter is a fixed quantity that helps define a relationship between variables but is not an input or output.

1.2 Identify a relationship as being a direct variation by examining its algebraic form, graph, and/or table of values.

1.2a A direct variation can be expressed in the algebraic form $y = kx$ where $k$ is a nonzero constant.

1.2b The graph of a direct variation whose domain is all real numbers is a non-vertical line that contains the origin $(0,0)$.

1.2c Two quantities vary directly if the ratio of the quantities is constant.

### Cross Connections
Direct variation is an extension of reasoning with proportional relationships, which students explored extensively in middle school. Students will have already solved context-free proportions in prior grades. Here, the focus is to analyze the proportional nature of the relationship and use it to solve real-world problems.

## Key Concept: Slope and Rate of Change

### Learning Objectives
*Students will be able to ...*

1.3 Identify a function as linear or nonlinear based on a numerical sequence whose indices have constant increments.

1.4 Use constant rate of change to create and graph linear functions.

### Essential Knowledge
*Students need to know that ...*

1.3a An arithmetic sequence is a linear function whose domain consists only of positive whole numbers.

1.3b The values of an arithmetic sequence in a table of values with constant step sizes display constant change from one row to the next.

1.3c Successive terms in an arithmetic sequence are obtained by adding the common difference to the previous term. To find the value of the term that occurs $n$ terms after a specified term, add to the specified term a quantity $n$ times the common difference.

1.4a The slope of a line can be used to generate all points on the line given any starting point.

1.4b If a table of values has a constant rate of change, then the points on the associated graph will lie on a line.
Learning Objectives
Students will be able to ...

1.5 Calculate the rate of change of a linear relationship.

Essential Knowledge
Students need to know that ...

1.5a The rate of change of the dependent variable with respect to the independent variable of a linear relationship is the slope of the line of the graph of the relationship.

1.5b The slope of a line can be calculated by finding the ratio of the vertical change to the horizontal change between any two ordered pairs with distinct \( x \)-coordinates using the formula

\[
m = \frac{y_2 - y_1}{x_2 - x_1}
\]

1.5c The slope can be interpreted in many ways via proportionality (e.g., \( y \) changes by \( m \) when \( x \) changes by 1, \( y \) changes by \( mk \) when \( x \) changes by \( k \), \( y \) changes by \( \Delta y = y_2 - y_1 \) when \( x \) changes by \( \Delta x = x_2 - x_1 \)).

1.5d The units attached to a rate of change have two components, expressed as the units of the dependent variable per the units of the independent variable.

Content Boundary: Knowing formulas associated with arithmetic sequences is beyond the scope of this course, but students should understand that a sequence is a function with whole-number inputs.

Cross Connections: Students may be familiar with the slope formula from their previous course. The focus here is on developing a thorough understanding of the rate of change of a linear relationship.

Key Concept: Linear Functions

Learning Objectives
Students will be able to ...

1.6 Determine whether a relationship between two variable quantities can be represented by a function.

1.7 Translate among different types of presentations of a function.

1.8 Identify whether a relationship is linear by examining the rate of change.

Essential Knowledge
Students need to know that ...

1.6a In a function, each value of one variable is related to exactly one value of a second variable.

1.6b A function can be presented graphically, numerically, algebraically, or by verbal description.

1.7a Different presentations of a function are appropriate for different purposes and reveal different information about the characteristics of the function.

1.7b An algebraic form of a function contains the complete information about the function.

1.7c The graphical and tabular presentations of a function usually do not contain complete information about the function.

1.8a In a table of linearly related values where the \( x \)-values differ by 1, consecutive \( y \)-values differ by a constant amount.

1.8b In a table of linearly related values where the \( x \)-values differ by varying amounts, the associated \( y \)-values will differ proportionally to these varying \( x \)-values.
<table>
<thead>
<tr>
<th><strong>Learning Objectives</strong></th>
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</table>
| **1.9** Identify and distinguish between the independent and dependent variables in a function. | **1.9a** The independent variable is the input for a function.  
**1.9b** The dependent variable is the output of a function. |
| **1.10** Determine a contextual domain and a range for a function. | **1.10a** The domain of a function is the set of all inputs for the function.  
**1.10b** The range of a function is the set of all outputs that result from the set of inputs for the function. |
| **1.11** Identify, construct, and/or interpret linear functions that represent both mathematical and real-world contexts. | **1.11a** Two points uniquely determine a linear function.  
**1.11b** A constant rate of change and a point on a line uniquely determine a linear function.  
**1.11c** Linear functions can model contextual situations that display a constant rate of change of the dependent variable with respect to the independent variable. |
| **1.12** Interpret solutions to mathematical models in context. | **1.12a** The solution to an equation or inequality derived from a context should involve the same units as the variables in the mathematical model. |
| **1.13** Use function notation to describe the relationship between an input–output pair of a function. | **1.13a** In the symbol "\( f(x) \)" the "\( f \)" is the name of the function, the "\( x \)" stands for any value in the domain of the function, and the "\( f(x) \)" represents the value in the range of the function that corresponds to the input \( x \).  
**1.13b** Any solution \((x, y)\) to the equation \( y = f(x) \) represents a point that lies on the graph of function \( f \). |
| **1.14** Construct a piecewise linear function to model a nonlinear contextual scenario. | **1.14a** A piecewise linear function consists of two or more linear functions, each one restricted to an interval of values in which the intervals are adjacent and not overlapping.  
**1.14b** Contextual scenarios that have different constant rates of change over different intervals of values can sometimes be modeled using a piecewise linear function. |

**Cross Connections:** Students will come to Algebra 1 with some prior knowledge about linear relationships. However, this knowledge might be procedural (e.g., how to calculate slope) or fragmented (e.g., not linking "\( y = mx + b \)" with the \( y \)-intercept of a line). This course guides students to consolidate and make connections among the disparate pieces of information they have relating to linear functions by understanding that constant rate of change is the defining feature of a linear relationship.

**Content Boundary:** Students should explore piecewise linear graphs that model scenarios that have a variety of constant rates of change over different intervals. Writing a single function expression for a piecewise function with multiple linear functions, such as \( f(x) = \begin{cases} 
2x - 5, & x < 0 \\
-3x + 6, & x \geq 0 
\end{cases} \) is beyond the scope of this course. Engaging with graphs of piecewise functions that have nonlinear components is also beyond the scope of this course.
## Key Concept: Linear Equations

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<td><strong>Students need to know that ...</strong></td>
</tr>
<tr>
<td>1.15 Use algebraic properties to rewrite expressions in equivalent forms.</td>
<td>1.15a The distributive property defines how addition and multiplication interact.</td>
</tr>
<tr>
<td></td>
<td>1.15b The additive identity element is 0. That is, adding 0 to any real number does not change the value of the number.</td>
</tr>
<tr>
<td></td>
<td>1.15c The multiplicative identity element is 1. That is, multiplying 1 to any real number does not change the value of the number.</td>
</tr>
<tr>
<td>1.16 Apply arithmetic properties of equality to obtain equivalent equations.</td>
<td>1.16a Simultaneously adding or subtracting a real number to both sides of an equation creates a new equation with equivalent solutions.</td>
</tr>
<tr>
<td></td>
<td>1.16b Multiplying or dividing both sides of an equation by a nonzero real number creates a new equation with equivalent solutions.</td>
</tr>
<tr>
<td></td>
<td>1.16c An equation can be solved in different ways, but the solution will be the same regardless of which method is used.</td>
</tr>
<tr>
<td>1.17 Rewrite a two-variable linear equation in terms of one of the variables to preserve the solution set.</td>
<td>1.17a The solution set to a two-variable equation, $Ax + By = C$, is the set of all ordered pairs $(m, n)$ such that substituting $m$ for $x$ and $n$ for $y$ into the equation makes the equation true.</td>
</tr>
<tr>
<td></td>
<td>1.17b Two-variable equations can be rewritten in different forms to reveal information about how the quantities relate to each other.</td>
</tr>
<tr>
<td>1.18 Interpret solutions to linear equations in context.</td>
<td>1.18a An equation derived from context can be solved free of context but the solution must be translated back to the context to interpret what the solution means.</td>
</tr>
<tr>
<td>1.19 Model a contextual scenario with a two-variable linear equation.</td>
<td>1.19a The number of variables needed to model a contextual scenario can be determined by the number of quantities related by the scenario.</td>
</tr>
<tr>
<td>1.20 Write an equation of a line using any algebraic form.</td>
<td>1.20a The standard form of a linear equation is $Ax + By = C$.</td>
</tr>
<tr>
<td></td>
<td>1.20b The point-slope form of a linear equation is $y = y_1 + m(x - x_1)$, or equivalently, $y - y_1 = m(x - x_1)$.</td>
</tr>
<tr>
<td></td>
<td>1.20c The slope-intercept form of a linear equation is $y = mx + b$.</td>
</tr>
<tr>
<td></td>
<td>1.20d A horizontal line has a slope of zero and its equation has the form $y = b$ where $b$ is the $y$-value of every point that lies on the line.</td>
</tr>
<tr>
<td></td>
<td>1.20e A vertical line has an undefined slope and its equation has the form $x = a$ where $a$ is the $x$-value of every point that lies on the line.</td>
</tr>
</tbody>
</table>
### Learning Objectives

**Students will be able to ...**

| 1.21 | Determine if the graphs of two linear equations are parallel or perpendicular by comparing their slopes. |

### Essential Knowledge

**Students need to know that ...**

| 1.21a | The slopes of parallel lines are equal, and two distinct lines with equal slopes are parallel. |
| 1.21b | The slopes of non-vertical and non-horizontal perpendicular lines are multiplicative inverses of each other with opposite signs. |
| 1.21c | A vertical line is perpendicular to a horizontal line, and vice versa. |

### Cross Connections:

In this key concept, students regard the two variables in a linear equation as two independent quantities related by a constraint; this is distinct from the input–output thinking that characterized the previous key concept. The scenarios students encounter through this key concept will relate two independent quantities through some kind of constraint of functions in one variable. Students should make connections with the one-variable equations they solved in middle school, understanding that both one-variable and two-variable equations are statements that can be either true or false.

### Key Concept: Scatterplots and Lines of Fit

#### Learning Objectives

**Students will be able to ...**

| 1.22 | Determine if a relationship between two quantities can be appropriately modeled by a linear function. |
| 1.23 | Estimate a line of fit for a scatterplot and write an equation for it. |
| 1.24 | Use the graph of a line of fit, or its equation, to predict values in context. |

#### Essential Knowledge

**Students need to know that ...**

| 1.22a | A scatterplot whose points fall roughly in a "surfboard" pattern can often be modeled usefully by a linear equation. |
| 1.22b | Sets of data that show a graphically upward trend (from left to right) are said to have a positive association. |
| 1.22c | Sets of data that show a graphically downward trend (from left to right) are said to have a negative association. |
| 1.23a | A line of fit is a line that closely approximates the data but may or may not contain any of the data points. |
| 1.23b | A line of fit is not an exact presentation of the modeled relationship; therefore, error should be expected. |
| 1.24a | A line of fit, but not a regression equation, can be used to estimate both independent and dependent quantities in context. |
| 1.24b | Relationships derived from data usually have limited domains beyond which the line of fit becomes an increasingly poor model. |

### Content Boundary:

Students should be able to determine if a linear model is appropriate given a scatterplot and to make and justify reasonable choices about how to construct a line that fits the data. Students could calculate the residuals of their line as one way to measure the appropriateness of fit, but doing so is beyond the scope of this course. Calculating a regression equation, either by hand or with technology, is beyond the scope of this course and should be reserved for Algebra 2 or beyond. The emphasis is on using (as opposed to constructing) the linear function model for the data.
## Key Concept: Linear Inequalities

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Essential Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.25</strong> Justify each step in solving a one-variable inequality.</td>
<td><strong>1.25a</strong> An inequality can be solved in different ways, but the solution will be the same regardless which method is used.</td>
</tr>
<tr>
<td></td>
<td><strong>1.25b</strong> The inequality relationship does not change when a real number is added to or subtracted from both sides of the inequality.</td>
</tr>
<tr>
<td></td>
<td><strong>1.25c</strong> The inequality relationship does not change when both sides of an inequality are multiplied or divided by a positive real number. The inequality relationship does change when both sides of an inequality are multiplied or divided by a negative real number.</td>
</tr>
<tr>
<td><strong>1.26</strong> Test a point to determine if it is a solution to a two-variable inequality.</td>
<td><strong>1.26a</strong> Inequalities can be rewritten in different forms to reveal information about how the quantities relate to each other.</td>
</tr>
<tr>
<td></td>
<td><strong>1.26b</strong> The solution set to an inequality in two variables, $x$ and $y$, is the set of all ordered pairs $(a, b)$ such that substituting $a$ for $x$ and $b$ for $y$ into the inequality makes the inequality true.</td>
</tr>
<tr>
<td><strong>1.27</strong> Graph the solution set for a two-variable inequality.</td>
<td><strong>1.27a</strong> The solution set to a two-variable inequality can be displayed graphically by a half-plane with or without its boundary. Any coordinate in the half-plane, and on its boundary if the boundary is included, is a solution to the inequality.</td>
</tr>
</tbody>
</table>

**Content Boundary:** Applications of two-variable linear inequalities are beyond the scope of this unit. They are addressed at the end of Unit 2: Systems of Linear Equations and Inequalities. This key concept focuses on the mechanics of graphing the solution set on a coordinate plane.
Unit 2: Systems of Linear Equations and Inequalities

Suggested Pacing: 5 weeks

Unit Overview

Across Unit 2, students are asked to solve systems of equations in support of two goals: to acquire an answer and to become strategic and efficient in choosing a method to solve the system. Students will build upon their prior knowledge of solving systems of equations by developing more sophisticated understandings about what the solution to a system means in context. Students will use systems of linear inequalities to model physical phenomena, especially those with multiple constraints where an optimal solution to an objective function is desired.

Unit 2 Enduring Understandings

Students will understand that ...

- Solving an equation or inequality is a process of determining the value or values that make the equation or inequality true.
- Algebraic manipulations can be used to transform algebraic equations and inequalities into equivalent equations and inequalities to reveal various aspects of the relationships present.
- Solutions to a system of equations or a system of inequalities simultaneously satisfy every equation or inequality in the system.
- Systems of linear equations or inequalities are useful for modeling scenarios that involve resource limitations, goals, constraints, comparisons, and tolerances.

Unit 2 Key Concepts

- Graphical and Numerical Solution Techniques
- Algebraic Solution Techniques
- Systems of Linear Inequalities
- Modeling with Systems of Equations and Inequalities
Key Concept: Graphical and Numerical Solution Techniques

**Learning Objectives**
*Students will be able to ...*

2.1 Solve a system of two-variable linear equations using graphical or tabular methods.

**Essential Knowledge**
*Students need to know that ...*

2.1a A system of two linear equations can have no solution, one solution, or infinitely many solutions.

2.1b If a solution to a system of linear equations exists, it will be the intersection point of its corresponding lines.

2.1c A solution to a system of linear equations, if it exists, corresponds to the \((x, y)\) pairs shared by the equations' table of values.

2.2 Determine the coordinate(s) \((x, y)\) of the intersection point(s) of the graphs of two functions \(f\) and \(g\).

2.2a The graphs of two functions \(f\) and \(g\) intersect at \(x\) if \(x\) is a value where \(f(x)\) and \(g(x)\) are equal.

2.2b The graphs of two functions \(f\) and \(g\) intersect at \(x\) if \(x\) is a value where \(f(x) - g(x) = 0\).

**Supporting Learning Objectives from Prior Unit**

1.1 Use letters or other symbols to represent variables and parameters.

1.4 Use constant rate of change to create and graph linear functions.

1.5 Calculate the rate of change of a linear relationship.

1.7 Translate among different types of presentations of a function.

1.9 Identify and distinguish between the independent and dependent variables in a function.

1.13 Use function notation to describe the relationship between an input–output pair of a function.

1.15 Use algebraic properties to rewrite expressions in equivalent forms.

1.16 Apply arithmetic properties of equality to obtain equivalent equations.

1.17 Rewrite a two-variable linear equation in terms of one of the variables to preserve the solution set.

1.18 Interpret solutions to linear equations in context.

1.20 Write an equation of a line using any algebraic form.

**Content Boundaries and Cross Connections:** In this unit, students will work with systems of two linear equations in two variables. In Unit 3: Quadratic Functions, students will be exposed to simple systems of one quadratic and one linear equation and to systems of two quadratic equations. Systems of three linear equations in three variables are beyond the scope of the Algebra 1 course and should be reserved for Algebra 2 or beyond.
## Key Concept: Algebraic Solution Techniques

### Learning Objectives
*Students will be able to ...*

| 2.3 | Solve a system of two-variable linear equations using algebraic methods. |

### Essential Knowledge
*Students need to know that ...*

| 2.3a | Substituting a variable for an expression, or an expression for a variable, can simplify solving an equation or a system of equations by revealing underlying structure. |
| 2.3b | Algebraic methods of solving a system of equations include the substitution method and the elimination method. |
| 2.3c | Some methods of solving a system of equations are more efficient than others, and the specific system of equations will determine which method is most appropriate. |

### Supporting Learning Objectives from Prior Units

1.1 Use letters or other symbols to represent variables and parameters.

1.7 Translate among different types of presentations of a function.

1.15 Use algebraic properties to rewrite expressions in equivalent forms.

1.16 Apply arithmetic properties of equality to obtain equivalent equations.

1.17 Rewrite a two-variable linear equation in terms of one of the variables to preserve the solution set.

1.18 Interpret solutions to linear equations in context.

1.20 Write an equation of a line using any algebraic form.

### Content Boundary:
The *focus* is to become strategic and efficient about choosing a particular method to solve the system. Students should come to understand that the graphical and tabular methods of solving a system of equations are inefficient and imprecise in most cases. Students should appreciate that the elimination method is convenient for linear equations written in standard form, but elimination is not generally applicable for nonlinear systems. The substitution method has wider utility for nonlinear systems. In this unit, students will only explore linear systems, but they need to develop fluency with the substitution method because it will become more important later in the course and in future courses. Other algebraic techniques, such as those involving matrices, are *beyond the scope* of this course and should be reserved for Algebra 2 or beyond.
Key Concept: Systems of Linear Inequalities

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>2.4</strong> Test a point to determine if it is a solution to a system of linear inequalities.</td>
<td><strong>2.4a</strong> A solution to a system of linear inequalities will make all inequalities that constitute the system true.</td>
</tr>
</tbody>
</table>
| **2.5** Graphically present the solutions to a system of two-variable linear inequalities. | **2.5a** A system of linear inequalities refers to a set of two-variable linear inequalities.  
**2.5b** The solution to a system of linear inequalities is the intersection of half-planes that correspond to the individual inequalities in the system, with or without its boundary or part of the boundary. Every point located in the solution region, or on the boundary if the boundary is included, is a solution to the system. |

Supporting Learning Objectives from Prior Units

- **1.1** Use letters or other symbols to represent variables and parameters.
- **1.15** Use algebraic properties to rewrite expressions in equivalent forms.
- **1.26** Test a point to determine if it is a solution to a two-variable inequality.
- **1.27** Graph the solution set for a two-variable inequality.

**Cross Connections:** Students should *make connections* with their knowledge from the previous unit and prior years to understand that any situation that involves an inequality is often best presented by a graphical presentation. That is, the solution to a one-variable linear inequality can be displayed as a shaded portion of a number line, the solution to a two-variable linear inequality can be displayed as a half-plane, and the solution to a system of two-variable linear inequalities can be displayed as the intersection of the associated half-planes.

**Content Boundary:** Systems of inequalities that involve nonlinear functions, such as quadratics or other polynomials, are *beyond the scope* of the Algebra 1 course and should be reserved for Algebra 2.
Key Concept: Modeling with Systems of Equations and Inequalities

<table>
<thead>
<tr>
<th>Learning Objectives</th>
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<tbody>
<tr>
<td><strong>2.6</strong> Model a contextual scenario with a system of linear equations or inequalities.</td>
<td><strong>2.6a</strong> A system of linear equations is useful for determining when two linear functions will have the same input–output pair.</td>
</tr>
<tr>
<td></td>
<td><strong>2.6b</strong> A system of linear equations is useful when two quantities are subject to two different sets of constraints.</td>
</tr>
<tr>
<td></td>
<td><strong>2.6c</strong> A system of linear inequalities is useful when modeling scenarios involving resource limitations, goals, constraints, comparisons, and tolerances.</td>
</tr>
</tbody>
</table>

**Supporting Learning Objectives from Prior Units**

1.1 Use letters or other symbols to represent variables and parameters.
1.4 Use constant rate of change to create and graph linear functions.
1.5 Calculate the rate of change of a linear relationship.
1.10 Determine a contextual domain and a range for a function.
1.12 Interpret solutions to mathematical models in context.
1.13 Use function notation to describe the relationship between an input–output pair of a function.
1.15 Use algebraic properties to rewrite expressions in equivalent forms.
1.17 Rewrite a two-variable linear equation in terms of one of the variables to preserve the solution set.
1.18 Interpret solutions to linear equations in context.
1.19 Model a contextual scenario with a two-variable linear equation.
1.20 Write an equation of a line using any algebraic form.
1.26 Test a point to determine if it is a solution to a two-variable inequality.
1.27 Graph the solution set for a two-variable inequality.

**Content Boundary and Cross Connections:** Students should model scenarios that can be represented by two linear equations. For scenarios that lend themselves to a system of linear inequalities, students should be able to determine an optimal solution. However, the formal process of linear programming is beyond the scope of this course as it requires significantly more knowledge than students have at this point.
Unit 3: Quadratic Functions

Suggested Pacing: 9 weeks

Unit Overview

In this unit, students will develop a strong foundation in the important concept of quadratic functions. Students will understand that quadratic functions are often formed by multiplying two linear expressions, and therefore are not linear. This foundational understanding of quadratics helps students build their conceptual knowledge of nonlinear functions and prepares them for further study of polynomial and rational functions in Algebra 2. This unit also helps students think about exponents and exponent rules, which are the focus of this course's culminating unit. Quadratic functions are useful for modeling phenomena that have a maximum or minimum value and exhibit symmetry, such as the motion of objects that are thrown upward and fall back to Earth.

Unit 3 Enduring Understandings

Students will know that ...

- A quadratic function is a function that is defined by a product of two linear expressions.
- Quadratic functions have a linear rate of change.
- The graph of a quadratic function is symmetric with respect to the vertical line containing its maximum or minimum.
- Every quadratic equation, $ax^2 + bx + c = 0$ where $a$ is not zero, can be solved with the quadratic formula, but those solutions may not be real numbers.

Unit 3 Key Concepts

- Modeling with Quadratic Functions
- Algebraic Forms of a Quadratic Function
- The Graph of a Quadratic Function
- Solving Quadratic Equations
### Key Concept: Modeling with Quadratic Functions

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>3.1</strong> Identify a function as quadratic or non-quadratic based on a numerical sequence whose indices have constant increments.</td>
<td><strong>3.1a</strong> The differences in values of a quadratic function in a table with constant step sizes, called the first differences, display a linear pattern.</td>
</tr>
<tr>
<td><strong>3.1b</strong> The second differences in a quadratic sequence are constant.</td>
<td><strong>3.1c</strong> Successive terms in a quadratic sequence can be obtained by adding corresponding successive terms of an arithmetic sequence.</td>
</tr>
<tr>
<td><strong>3.2</strong> Use a quadratic function to model a contextual scenario and answer questions about the scenario.</td>
<td><strong>3.2a</strong> Scenarios involving gravity or any other accelerated motions are often well-modeled by a quadratic function.</td>
</tr>
<tr>
<td><strong>3.2b</strong> Scenarios involving area are often well-modeled by a quadratic function.</td>
<td><strong>3.2c</strong> Many scenarios involving symmetric curves can be practically modeled with quadratics (e.g., suspension bridges, profit and loss, solar collectors).</td>
</tr>
<tr>
<td><strong>3.3</strong> Interpret the vertex and zeros of a quadratic model in context.</td>
<td><strong>3.3a</strong> The $y$-value of the vertex of a parabola often represents the minimum or maximum value (of the dependent variable) in a contextual scenario.</td>
</tr>
<tr>
<td><strong>3.3b</strong> The $x$-values of the zeros of a parabola often represent the extreme values (of the independent variable) in a contextual scenario.</td>
<td></td>
</tr>
</tbody>
</table>

### Supporting Learning Objectives from Prior Units

- **1.1** Use letters or other symbols to represent variables and parameters.
- **1.5** Calculate the rate of change of a linear relationship.
- **1.6** Determine whether a relationship between two variable quantities can be represented by a function.
- **1.7** Translate among different types of presentations of a function.
- **1.10** Determine a contextual domain and a range for a function.
- **1.12** Interpret solutions to mathematical models in context.
- **1.13** Use function notation to describe the relationship between an input–output pair of a function.
- **1.15** Use algebraic properties to rewrite expressions in equivalent forms.
- **1.16** Apply arithmetic properties of equality to obtain equivalent equations.
- **2.2** Determine the coordinate(s) $(x, y)$ of the intersection point(s) of the graphs of two functions $f$ and $g$.

### Cross Connections:
This key concept motivates the need for a nonlinear function to represent situations that cannot be adequately expressed with a linear function, such as gravity or area. Students should understand that any scenario, physical or otherwise, that involves multiplying two linear functions will be quadratic. Earlier in Algebra 1, students saw that physical scenarios that exhibit a constant rate of change can be modeled by a linear function. In AP Calculus and AP Physics, students will come to understand that particle motion problems that exhibit a constant acceleration can be modeled by a quadratic function.
### Key Concept: Algebraic Forms of a Quadratic Function

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>3.4</strong> Use the distributive property to rewrite expressions in equivalent forms.</td>
<td><strong>3.4a</strong> An expression ( A ) is a factor of expression ( B ) if there is another expression ( C ) where the product ( AC ) is equivalent to ( B ).</td>
</tr>
<tr>
<td><strong>3.4b</strong> Just as composite numbers may have multiple correct factorizations, an algebraic expression may have multiple correct factored forms.</td>
<td><strong>3.4c</strong> A factored form of an expression is equivalent to an expanded form of the expression.</td>
</tr>
<tr>
<td><strong>3.4d</strong> The distributive property explains how to expand products of expressions involving two or more terms. That is, ((a + b)(c + d) = (a + b)c + (a + b)d = ac + bc + ad + bd).</td>
<td></td>
</tr>
<tr>
<td><strong>3.5</strong> Express a quadratic function as the product of two linear expressions.</td>
<td><strong>3.5a</strong> The factored form of a quadratic function is ( f(x) = a(x - r)(x - s), a \neq 0 ).</td>
</tr>
<tr>
<td><strong>3.5b</strong> The standard form of a quadratic function is ( f(x) = ax^2 + bx + c, a \neq 0 ).</td>
<td></td>
</tr>
<tr>
<td><strong>3.6</strong> Determine the factored form of a quadratic function given points from the graph of the function.</td>
<td><strong>3.6a</strong> The equation of a parabola is uniquely determined by any three points that lie on the parabola.</td>
</tr>
<tr>
<td><strong>3.6b</strong> The zeros of a parabola are two convenient points that, with a third point, can be used to determine the equation of the parabola.</td>
<td></td>
</tr>
<tr>
<td><strong>3.7</strong> Complete the square to write a quadratic function in vertex form.</td>
<td><strong>3.7a</strong> The vertex form of a quadratic function is ( f(x) = a(x - h)^2 + k, a \neq 0 ).</td>
</tr>
<tr>
<td><strong>3.7b</strong> The parameters of the vertex form of a quadratic expression provide the coordinate of the vertex of the parabola ( (h, k) ).</td>
<td><strong>3.7c</strong> Every quadratic function has a standard form and a vertex form, but not always a factored form over the real number system.</td>
</tr>
<tr>
<td><strong>3.8</strong> Determine the vertex form of a quadratic function given appropriate points from the graph of the function.</td>
<td><strong>3.8a</strong> The equation of a parabola can be determined given the vertex and another point on the parabola.</td>
</tr>
</tbody>
</table>

### Supporting Learning Objectives from Prior Units

1. **1.1** Use letters or other symbols to represent variables and parameters.
2. **1.7** Translate among different types of presentations of a function.
3. **1.13** Use function notation to describe the relationship between an input–output pair of a function.
4. **1.15** Use algebraic properties to rewrite expressions in equivalent forms.
5. **1.16** Apply arithmetic properties of equality to obtain equivalent equations.

**Content Boundary:** Quadratic functions can be written in many forms, and each form reveals or obscures certain features of the quadratic. The focus here should be having students master the ability to translate among these representations and choose the representation that best serves the problem at hand. Fluent skill in transforming one algebraic form into another will help students in Algebra 2 and beyond in looking for structure of polynomial and rational functions. However, rote exercises are less effective at producing fluency than exercises where the student purposefully transforms expressions for a specific reason.
### Key Concept: The Graph of a Quadratic Function

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>3.9</strong> Identify key characteristics of the graph of a quadratic function.</td>
<td><strong>3.9a</strong> The graph of a quadratic function is a parabola with a vertical line of symmetry passing through its vertex and is either concave up or concave down.</td>
</tr>
<tr>
<td></td>
<td><strong>3.9b</strong> The graph of a quadratic function has at most two x-intercepts.</td>
</tr>
<tr>
<td></td>
<td><strong>3.9c</strong> The x-coordinate of the vertex of a parabola can be calculated with the formula ( x_{\text{vertex}} = \frac{-b}{2a} ) using parameters from the standard form of a quadratic function.</td>
</tr>
<tr>
<td></td>
<td><strong>3.9d</strong> The y-coordinate of the vertex of a parabola can be calculated using the x-coordinate of the vertex and substitution.</td>
</tr>
</tbody>
</table>

| **3.10** Use the zeros of a quadratic function to find the vertex of the associated parabola. | **3.10a** The x-coordinate of the vertex of a parabola is located exactly halfway between the x-intercepts of the parabola, if two x-intercepts exist. |
| **3.11** Relate the x-intercepts of a parabola to the factored form of a quadratic function. | **3.11a** A quadratic function whose factored form is \( f(x) = a(x - r)(x - s) \), where \( a \neq 0 \), will have two x-intercepts at \((r,0)\) and \((s,0)\), as long as \( r \neq s \). |
| **3.12** Relate the x-intercepts of parabola \( f(x) = ax^2 + bx + c \) to the solutions of a quadratic equation \( ax^2 + bx + c = 0 \). | **3.12a** Translating a parabola either vertically up or vertically down shows that a quadratic function can have at most two x-intercepts, exactly one x-intercept, or no x-intercepts. |
| | **3.12b** If a quadratic equation \( ax^2 + bx + c = 0 \) has real solutions \( x = p \) and \( x = q \), then the quadratic function \( f(x) = ax^2 + bx + c \) has x-intercepts at \((p,0)\) and \((q,0)\). |

### Supporting Learning Objectives from Prior Units

1. **1.1** Use letters or other symbols to represent variables and parameters.
2. **1.7** Translate among different types of presentations of a function.
3. **1.13** Use function notation to describe the relationship between an input–output pair of a function.
4. **1.16** Apply arithmetic properties of equality to obtain equivalent equations.

### Content Boundary:
It is possible to orient a parabola so it opens to the left or right. However, the associated equations would not be functions of \( x \) and are beyond the scope of this course. This should be left for when students more thoroughly explore conic sections in Algebra 2 or beyond.

### Cross Connections:
Students should recognize a very close connection between the algebraic forms of a quadratic function and the graph of a parabola.
## Key Concept: Solving Quadratic Equations

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>3.13</strong> Solve quadratic equations by taking a square root.</td>
<td><strong>3.13a</strong> The symbol ( \sqrt{a} ) is called the square root of ( a ) and refers only to the principal, or positive, number whose square equals ( a ).</td>
</tr>
<tr>
<td></td>
<td><strong>3.13b</strong> For any positive real number ( a ), there are two real numbers that satisfy the equation ( x^2 = a ), one positive and one negative.</td>
</tr>
<tr>
<td></td>
<td><strong>3.13c</strong> There is no real number that will satisfy the equation ( x^2 = a ), when ( a ) is a negative real number.</td>
</tr>
<tr>
<td><strong>3.14</strong> Solve quadratic equations by factoring.</td>
<td><strong>3.14a</strong> Applying the zero product property, the solutions of a quadratic equation ( (x - r)(x - s) = 0 ) are ( x = r ) and ( x = s ).</td>
</tr>
<tr>
<td></td>
<td><strong>3.14b</strong> Factoring a quadratic expression yields an equivalent form of the expression that can be used to determine the roots of the associated quadratic equation.</td>
</tr>
<tr>
<td></td>
<td><strong>3.14c</strong> Not all quadratic equations have rational solutions, so not all quadratic equations can be factored into linear factors with integer coefficients.</td>
</tr>
<tr>
<td><strong>3.15</strong> Solve quadratic equations by completing the square.</td>
<td><strong>3.15a</strong> Completing the square is an algebraic process of transforming a quadratic function into a form that can be solved with elementary operations of adding, multiplying, and taking square roots.</td>
</tr>
<tr>
<td></td>
<td><strong>3.15b</strong> All quadratic equations can be solved by completing the square, but the solutions may not be real numbers.</td>
</tr>
<tr>
<td><strong>3.16</strong> Solve quadratic equations by using the quadratic formula.</td>
<td><strong>3.16a</strong> The quadratic formula, ( x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} ), can be used to solve any quadratic equation using the parameters of the standard form of the quadratic equation, but these solutions may not be real numbers.</td>
</tr>
<tr>
<td></td>
<td><strong>3.16b</strong> The quadratic formula can be derived from completing the square with the standard form of a quadratic equation, ( ax^2 + bx + c = 0 ).</td>
</tr>
<tr>
<td></td>
<td><strong>3.16c</strong> The value of the discriminant of the quadratic ( D = b^2 - 4ac ) determines if the solutions to a quadratic equation are two distinct real solutions ( (D &gt; 0) ), one real solution ( (D = 0) ), or no real solutions ( (D &lt; 0) ).</td>
</tr>
</tbody>
</table>
Supporting Learning Objectives from Prior Units

1.1 Use letters or other symbols to represent variables and parameters.

1.15 Use algebraic properties to rewrite expressions in equivalent forms.

1.16 Apply arithmetic properties of equality to obtain equivalent equations.

2.2 Determine the coordinate(s) \((x, y)\) of the intersection point(s) of the graphs of two functions \(f\) and \(g\).

**Content Boundary:** The focus here is on having students making explicit connections between the real number solutions of a quadratic equation and the \(x\)-intercept(s) of the associated graph. Students should understand that all quadratic equations can be solved, but some quadratic equations require a new number system to adequately express the solution set. However, imaginary numbers are beyond the scope of this course. Students should not be expected to perform arithmetic with imaginary numbers. This should be reserved for Algebra 2.
Unit 4: Exponent Properties and Exponential Functions

Suggested Pacing: 5 weeks

Unit Overview

Students will explore exponent rules as an extension of geometric sequences and the properties of multiplication and division for real numbers. Students should make sense of exponent rules and not simply memorize them without understanding how they arise. The unit culminates in students investigating how exponential functions can model physical phenomena that exhibit a constant ratio of growth. Exponential functions are framed as multiplicative analogues of linear functions. Thus, a tight connection should be drawn between these two classes of functions and their shared properties.

Unit 4 Enduring Understandings

- The set of real numbers can be divided into rational numbers (numbers with terminating or repeating decimal presentations) and irrational numbers (numbers with nonterminating and nonrepeating decimal presentations).
- Exponent properties are derived from the properties of multiplication and division.
- Exponential functions can be used to model physical scenarios that involve constant multiplicative growth or decay.

Unit 4 Key Concepts

- Exponent Rules and Properties
- Roots of Real Numbers
- Exponential Growth and Decay
## Key Concept: Exponent Rules and Properties

### Learning Objectives

<table>
<thead>
<tr>
<th>Students will be able to ...</th>
<th>Essential Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Use the laws of exponents to express products and quotients of exponential expressions in equivalent forms.</td>
<td>4.1a Exponential expressions involving multiplication can be rewritten by invoking the rule ( n^a \cdot n^b = n^{a+b} ).</td>
</tr>
<tr>
<td> </td>
<td>4.1b Exponential expressions involving division can be rewritten by invoking the rule ( \frac{n^a}{n^b} = n^{a-b} ).</td>
</tr>
<tr>
<td> </td>
<td>4.1c Exponential expressions involving powers of powers can be rewritten by invoking the rule ( (n^a)^b = n^{ab} ).</td>
</tr>
<tr>
<td>4.2 Use the laws of exponents to express numerical and variable expressions that involve negative exponents with positive exponents, and vice versa.</td>
<td>4.2a A negative exponent can be used to represent a reciprocal. That is, ( \frac{1}{n} = n^{-1} ).</td>
</tr>
<tr>
<td> </td>
<td>4.2b Any real number (except 0) raised to the zero power is equal to 1. That is, ( n^0 = 1 ), for ( a \neq 0 ).</td>
</tr>
<tr>
<td> </td>
<td>4.2c Zero and negative powers are extensions of the properties of whole number exponents.</td>
</tr>
</tbody>
</table>

### Supporting Learning Objectives from prior units

1.1 Use letters or other symbols to represent variables and parameters.

1.15 Use algebraic properties to rewrite expressions in equivalent forms.

### Content Boundary:

Students coming to Algebra 1 may be familiar with negative exponents from working with scientific notation in middle school, but their skills could be limited to surface knowledge like "moving the decimal point." The focus here is for students to develop these formulas through extending the properties of multiplication and division. Students should not be expected to simplify excessively complicated quotients, such as \( \frac{36x^3y^{-4}z^7}{72x^{-3}y^6z^8} \), because these expressions have limited usefulness outside of rote skill acquisition.

### Cross Connections:

Students should be able to flexibly and fluently translate among different forms of expressions involving exponents. For example, often in AP Calculus it is advantageous to rewrite the function \( f(x) = \frac{1}{x^2} \) as \( f(x) = x^{-2} \).

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Pre-AP Algebra 1  COURSE GUIDE

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### Key Concept: Roots of Real Numbers

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Essential Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.3</strong> Perform operations with rational and irrational numbers.</td>
<td><strong>4.3a</strong> The exact value of an irrational number cannot be expressed as a ratio of integers nor in decimal form as a nonrepeating, nonterminating decimal, and is often represented exactly by a symbol, such as $\pi$ or $\sqrt{2}$.</td>
</tr>
<tr>
<td><strong>4.3b</strong> Irrational numbers can be approximated arbitrarily closely by rational numbers.</td>
<td></td>
</tr>
<tr>
<td><strong>4.4</strong> Express square roots of real numbers in equivalent forms.</td>
<td><strong>4.4a</strong> If a positive real number $a$ can be written as the square of another number, that is, if $a = b^2$, then $\sqrt{a} = \sqrt{b^2} = b$ where $b$ is positive.</td>
</tr>
<tr>
<td><strong>4.4b</strong> If a positive real number $a$ can be written as a product of a square and another number, that is, if $a = b^2 \cdot c$, then $\sqrt{a} = \sqrt{b^2} \cdot \sqrt{c} = b\sqrt{c}$ where $a$, $b$, and $c$ are all positive.</td>
<td></td>
</tr>
<tr>
<td><strong>4.4c</strong> For any two positive real numbers $a$ and $b$, $\sqrt{a} \cdot \sqrt{b} = \sqrt{ab}$.</td>
<td></td>
</tr>
<tr>
<td><strong>4.5</strong> Use the laws of exponents to express roots of real numbers in terms of rational number powers.</td>
<td><strong>4.5a</strong> The square root of a nonnegative real number can be expressed with the exponent $\frac{1}{2}$. That is, $\sqrt{n} = n^{\frac{1}{2}}$ where $n \geq 0$.</td>
</tr>
<tr>
<td><strong>4.5b</strong> The cube root of any real number can be expressed with the exponent $\frac{1}{3}$. That is, $\sqrt[3]{n} = n^{\frac{1}{3}}$.</td>
<td></td>
</tr>
<tr>
<td><strong>4.5c</strong> Rational exponents generalize integer exponents and obey the same properties.</td>
<td></td>
</tr>
</tbody>
</table>

### Supporting Learning Objectives from Prior Units

1. **1.1** Use letters or other symbols to represent variables and parameters.
2. **1.15** Use algebraic properties to rewrite expressions in equivalent forms.
3. **3.13** Solve quadratic equations by taking a square root.

**Content Boundary:** The focus here is on having students understand that "simplifying" a square root is similar to reducing a fraction to lowest terms. That is, $\sqrt{8}$ expresses the same quantity as $2\sqrt{2}$, just as $\frac{6}{8}$ expresses the same quantity as $\frac{3}{4}$. It is not absolutely necessary to reduce a fraction to lowest terms and it is not absolutely necessary to simplify a square root to "lowest terms." Different equivalent forms of numbers exist and the context of the problem will suggest when one form could be better than another one.

**Cross Connections:** Students should start to identify circumstances when a particular form of a number provides an insight or advantage that other forms do not. In AP Calculus, students will often find it helpful to rewrite the functions $g(x) = \sqrt{x}$ using an exponent, $g(x) = x^{\frac{1}{2}}$. 

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Pre-AP Algebra 1 Course Framework

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# Key Concept: Exponential Growth and Decay

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Essential Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.6</strong> Identify a function as exponential or non-exponential based on a numerical sequence whose indices have constant increments.</td>
<td><strong>4.6a</strong> A geometric sequence is an exponential function whose domain consists only of positive whole numbers.</td>
</tr>
<tr>
<td><strong>4.6b</strong> The ratio of successive values of an exponential function in a table of values with constant step sizes is constant.</td>
<td><strong>4.6c</strong> Successive terms in a geometric sequence are obtained by multiplying the constant ratio to the previous term.</td>
</tr>
<tr>
<td><strong>4.7</strong> Write an algebraic form of an exponential function given a table of values.</td>
<td><strong>4.7a</strong> The algebraic form of an exponential function is ( f(x) = a \cdot c^x ), where ( c ) is the ratio of growth or decay.</td>
</tr>
<tr>
<td><strong>4.8</strong> Graph an exponential function given a table of values or its algebraic form.</td>
<td><strong>4.8a</strong> The graph of an exponential function is a curved line that exhibits asymptotic behavior to the left or the right.</td>
</tr>
<tr>
<td><strong>4.9</strong> Model a physical scenario with an exponential function.</td>
<td><strong>4.9a</strong> Scenarios that exhibit multiplicative growth or decay can be modeled by an exponential function.</td>
</tr>
</tbody>
</table>

**Supporting Learning Objectives from prior units**

| 1.1 | Use letters or other symbols to represent variables and parameters. |
| 1.6 | Determine whether a relationship between two variable quantities can be represented by a function. |
| 1.7 | Translate among different types of presentations of a function. |
| 1.9 | Identify and distinguish between the independent and dependent variables in a function. |
| 1.10 | Determine a contextual domain and a range for a function. |
| 1.12 | Interpret solutions to mathematical models in context. |
| 1.13 | Use function notation to describe the relationship between an input–output pair of a function. |
| 1.15 | Use algebraic properties to rewrite expressions in equivalent forms. |
| 1.16 | Apply arithmetic properties of equality to obtain equivalent equations. |

**Content Boundary:** The goal of introducing students to geometric sequences is to have them investigate multiplicative patterns as a counterpoint to the additive patterns of linear and quadratic sequences. The focus should be on using their knowledge of multiplicative patterns to explore simple exponential growth and decay relationships. Students will be expected to generate a table of values, construct a graph, and write an algebraic representation of an exponential function. Students should not solve problems involving formulas relating to geometric sequences, compound interest, or logarithms as these topics are beyond the scope of this course and are topics for Algebra 2.
The Pre-AP Instructional Approach

Pre-AP course frameworks articulate the essential knowledge, skills, and practices all students need to be prepared for college and a career. In short, the frameworks outline the *what* in terms of the content and skills teachers should prioritize. The Pre-AP teacher, in turn, breathes life into the course by defining the *how*—creating the learning opportunities that allow students to build, practice, and strengthen the skills that will reward them throughout their high school coursework and prepare them for their futures.

The Pre-AP teacher’s role is to translate what lives in this framework into classroom learning. The Pre-AP course resources help teachers do that by modeling effective strategies and approaches that they can adapt and leverage throughout the course. The teacher-facing lessons and student resources (available to schools participating in the official Pre-AP Program) provide concrete models of how to apply the course framework and instructional principles to daily instruction.

This section describes the overall Pre-AP instructional approach, or philosophy, to serve as a reference or guide for all teachers seeking to align their instruction to Pre-AP goals and principles. The following components bring shape, focus, and meaning to Pre-AP courses, while honoring and preserving the space and flexibility for teachers' instructional decision making:

- **Shared principles:** Instructional routines and strategies that unite all Pre-AP courses
- **Areas of focus:** Discipline-specific instructional priorities for the course
- **Instructional resources:** Overview of the lessons and resources that are provided to teachers participating in the official Pre-AP Program
- **Recommended unit structure:** A model for structuring and sequencing units in the course

Pre-AP course teachers will receive more detailed course maps and planning tools through the digital resources and professional learning institute that comes with official program participation.
Areas of Focus

In addition to the shared principles, each Pre-AP course focuses on a small set of discipline-specific instructional priorities that support both teacher practice and student learning within the discipline. These areas of focus reflect research-supported practices that should receive greater emphasis in instructional materials and assessments than they often do. Pre-AP recognizes that many teachers and schools already embrace these priorities, and now we are offering resources that specifically emphasize these areas of focus.

Pre-AP Algebra 1 Areas of Focus:

- **Mastery of linear equations and linear functions**: Students develop a deep and robust understanding of linear relationships from procedural, conceptual, and applied perspectives.
- **Greater authenticity of applications and modeling**: Students create and use mathematical models to understand and explain authentic scenarios.
- **Engagement in mathematical argumentation**: Students use evidence to craft mathematical conjectures and prove or disprove them.

Unpacking the Areas of Focus

**Mastery of Linear Equations and Linear Functions**

Linear relationships are among the most prevalent and useful relationships in mathematics and in the real world. An appreciation for both the power and simplicity of linear functions is a foundational building block for success in higher-level mathematics courses. Therefore, the study of linear relationships takes center stage in this course as an instructional priority.

**Greater Authenticity of Applications and Modeling**

Mathematical modeling is a powerful tool that helps students explain the world. Students will explore real-world contexts where mathematics naturally occurs. Students will engage in the modeling process, which involves making choices about what to model about a phenomenon, assessing how well the model captures the available data, and exploring what the model helps clarify and what it does not.
**Engagement in Mathematical Argumentation**

Conjecture and proof lie at the heart of the discipline of mathematics. Students will gain experience making observations, looking for patterns, forming conjectures, and proving or disproving their hypotheses. Through mathematical argumentation, students learn how to be critical of their own reasoning and the reasoning of others.

**Instructional Resources**

Schools that officially implement a Pre-AP course will receive access to instructional resources for each unit. These resources do not constitute a full day-by-day curriculum. Instead, they provide significant support and modeling for teachers as they design instruction for each unit.

Pre-AP Algebra 1 offers the following types of instructional resources:

**Lesson Sets**

Lesson sets provide teachers and students with a recommended multiday sequence of scaffolded instruction—starting and ending with formative assessments to gauge student learning. Each lesson set contains between two and four individual lessons designed to be implemented over several consecutive days. Lessons target specific key concepts where building a strong foundation in mathematics is most important.

**Practice Problem Sets**

Practice problem sets provide students with opportunities to practice and apply what they've learned. These problem sets tailored to the lesson content supplement many of the Pre-AP Algebra 1 lessons. They often extend the contextualized scenarios from the lesson, and present innovative opportunities for students to apply their new knowledge. Problem sets help students practice both concepts and skills.

Some students will need additional assistance with more fundamental concepts. Pre-AP Algebra 1 lessons offer targeted links to Khan Academy resources to help students build a solid foundation of mathematical knowledge.

Please visit [pre-ap.collegeboard.org](http://pre-ap.collegeboard.org) for more information.
Overview

Pre-AP assessments are frequent and varied so that they become a natural part of the classroom experience and a source of meaningful feedback. Teachers and students can use the assessments, which are all based on the course framework, to understand and track progress and to identify where additional practice or support might be needed. Since students encounter a range of assessments throughout the course, progress isn't measured by performance on any single exam. Rather, Pre-AP offers a place to practice, to grow, and to recognize that learning takes time.

Unit Quizzes: Each unit includes two short online quizzes featuring multiple-choice questions modeled closely after the types of questions students encounter on SAT and AP exams. Based on the Pre-AP Algebra 1 course framework, digital unit quizzes require students to examine graphs, data, and short texts—all set in authentic contexts—in order to respond to a targeted set of questions that measure both the key concepts and skills from the unit. All eight objective quizzes are machine-scored, with results provided through automatic score reports that contain explanations of all questions and answers and actionable feedback.

Performance Tasks: Each unit includes one performance-based assessment as well as a practice performance task. Algebra 1 performance tasks are modeled after the free-response questions for AP Calculus and AP Statistics. These tasks engage students in sustained problem solving and ask them to synthesize skills and concepts from across the unit to answer questions about a novel context.

Developed for ninth graders in an open access environment, Pre-AP performance tasks are accessible and appropriate while still providing sufficient challenge and the opportunity to practice the analytical skills that will be required in AP mathematics courses, as well as for college and career readiness. To support practice and skill building, each unit also includes a practice performance task to provide students time to engage with these open-ended assessments prior to the final performance assessment in the unit.

These unit quizzes and performance tasks will be updated and refreshed on a periodic basis to ensure the strength, quality, and value of these assessment resources.

Teachers participating in the official Pre-AP Program will receive access to online learning modules to support them in evaluating student work for each performance task. These on-demand experiences will orient teachers to the content of the task and the scoring guide requirements and will engage them in scoring student work samples in preparation for evaluating their own students' work.
Inside the Assessment Blueprint

The following tables provide a synopsis of key content dimensions of the Pre-AP Algebra 1 unit quizzes.

<table>
<thead>
<tr>
<th><strong>BLUEPRINT</strong></th>
</tr>
</thead>
</table>
| **Format** | Two machine-scored objective quizzes per unit  
Digitally administered with automated scoring and reporting  
Questions that target both concepts and skills from the course framework |
| **Time Allocated** | One 45-minute class period per quiz |
| **Length** | 10–15 questions per assessment |
| **Multiple Choice (4 answer choices)** | 100% |
| **Stimulus Based** | 100% |

<table>
<thead>
<tr>
<th><strong>Domains Assessed</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
</tr>
</tbody>
</table>
| **Skills** | The following skills are assessed with regular frequency across all four units:  
- Developing conceptual understanding  
- Building procedural fluency  
- Making and using mathematical models  
- Crafting mathematical arguments |
| **Question Types** |  
- Question types are modeled after PSAT/SAT and AP test questions.  
- Question sets are organized around two or three questions that focus on a single stimulus, such as a text, graph, or table.  
- Questions embed mathematical concepts in real world contexts. |
<table>
<thead>
<tr>
<th>Unit</th>
<th>Assessment</th>
<th>Content Domain (Key Concepts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Unit 1 Quiz 1</td>
<td>Direct Variation</td>
</tr>
<tr>
<td>Linear Equations and Linear Functions</td>
<td></td>
<td>Slope and Rate of Change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear Functions</td>
</tr>
<tr>
<td>Unit 1 Quiz 2</td>
<td></td>
<td>Linear Functions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear Equations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scatterplots and Lines of Fit</td>
</tr>
<tr>
<td>Unit 1 Performance Task</td>
<td></td>
<td>Scatterplots and Lines of Fit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 2</td>
<td>Unit 2 Quiz 1</td>
<td>Graphical and Numerical Solution Techniques</td>
</tr>
<tr>
<td>Systems of Linear Equations and Inequalities</td>
<td></td>
<td>Algebraic Solution Techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modeling with Systems of Equations and Inequalities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(focus: systems of equations)</td>
</tr>
<tr>
<td>Unit 2 Quiz 2</td>
<td></td>
<td>Linear Inequalities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Systems of Linear Inequalities</td>
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<tr>
<td></td>
<td></td>
<td>Modeling with Systems of Equations and Inequalities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(focus: systems of inequalities)</td>
</tr>
<tr>
<td>Unit 2 Performance Task</td>
<td></td>
<td>Modeling with Systems of Equations and Inequalities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 3</td>
<td>Unit 3 Quiz 1</td>
<td>Algebraic Forms of a Quadratic Function</td>
</tr>
<tr>
<td>Quadratic Functions</td>
<td></td>
<td>The Graph of a Quadratic Function</td>
</tr>
<tr>
<td>Unit 3 Quiz 2</td>
<td></td>
<td>Modeling with Quadratic Functions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Algebraic Forms of a Quadratic Function</td>
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<tr>
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<td></td>
<td>The Graph of a Quadratic Function</td>
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<tr>
<td></td>
<td></td>
<td>Solving Quadratic Equations</td>
</tr>
<tr>
<td>Unit 3 Performance Task</td>
<td></td>
<td>Modeling with Quadratic Functions</td>
</tr>
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</tr>
<tr>
<td>Unit 4</td>
<td>Unit 4 Quiz 1</td>
<td>Exponent Rules and Properties</td>
</tr>
<tr>
<td>Exponent Properties and Exponential Functions</td>
<td></td>
<td>Roots of Real Numbers</td>
</tr>
<tr>
<td>Unit 4 Quiz 2</td>
<td></td>
<td>Exponential Growth and Decay</td>
</tr>
<tr>
<td>Unit 4 Performance Task</td>
<td></td>
<td>Exponential Growth and Decay</td>
</tr>
</tbody>
</table>

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Pre-AP Algebra 1 Assessments

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38
Sample Unit Quiz Questions

1. Annie runs a lemonade stand at the flea market each Saturday. Annie’s Lemonade makes a profit of $90 when it sells 100 glasses of lemonade and $140 when it sells 140 glasses of lemonade. What is the rate of change of this scenario, in terms of Annie’s profit per glass of lemonade?
   (A) $0.80 per glass of lemonade
   (B) 0.80 glasses of lemonade per dollar
   (C) $1.25 per glass of lemonade
   (D) 1.25 glasses of lemonade per dollar

2. Viruses can infiltrate the membrane of a cell, start multiplying by using the cell’s own resources, and eventually cause the cell to burst. The graph below shows the time it takes for a particular virus to penetrate the surface of a cell.

   ![Graph showing the time it takes for a virus to penetrate the surface of a cell.]

   What is the value of the viral distance unit intercept and what does it mean?
   (A) 9; the time it takes to enter the cell when the virus distance is zero
   (B) 9; the thickness of the cell membrane when the virus begins its infiltration
   (C) 7; the distance the virus is from the membrane of the cell
   (D) 7; the thickness of the cell membrane
1. Kelsey is purchasing beads for an art project. The supply store sells the beads in bulk in multicolor assortments. Kelsey only wants to use blue beads for her project but the store won't allow her to pick through the beads to get only blue ones. She takes five small samples of varying weight and counts the number of blue beads in each sample. The scatter plot represents Kelsey's findings.

To determine an equation for the line of fit, Kelsey uses two points that she thinks lie on the line: the number of blue beads for a sample that measures 0.6 ounces and the number of blue beads for a sample that measures 2 ounces. Which is the equation of the line of fit for Kelsey’s scatterplot?

(A) \( y = \frac{16}{1.4} x - \frac{41}{7} \)

(B) \( y = \frac{15}{1.4} x - \frac{38}{7} \)

(C) \( y = \frac{1.4}{16} x + \frac{673}{400} \)

(D) \( y = \frac{1.4}{15} x - \frac{1186}{75} \)

**Assessment Focus**

This question assesses whether or not students can write the equation of the line of best fit. Students must also translate between information provided in the stimulus text and the scatterplot.

**Correct Answer: A**

**Learning Objective 1.23:**
Estimate a line of fit for a scatterplot and write an equation for it.

**Skill:** Procedural Fluency
1. Laura is a general contractor who needs to order some plywood to complete a house she is building. Laura needs at least 110 sheets of plywood. There are two supply companies, Menureds and HouseCo, and neither one has enough materials. Menureds sells plywood in bundles of 3 sheets, and they have 12 bundles available, which cost $72 each. HouseCo sells their plywood in bundles of 4 sheets and they have 25 bundles available at $76 per bundle.

If Laura has only budgeted $2,500 for plywood, what is the best plan that will get her at least 110 sheets under budget?

(A) 12 bundles from Menureds and 18.5 bundles from HouseCo
(B) 10 bundles from Menureds and 20 bundles from HouseCo
(C) 12 bundles from Menureds and 25 sheets from HouseCo
(D) 5 bundles from Menureds and 24 bundles from HouseCo

Assessment Focus
This problem assesses whether or not students can represent and model a scenario involving a simple system of inequalities and interpret potential solutions.

Correct Answer: D

Learning Objective 2.4:
Test a point to determine if it is a solution to a system of linear inequalities.

Skill: Mathematical Modeling
Pre-AP Performance Tasks

Space for Mathematical Argumentation

Performance tasks provide the needed time and space for students to truly use their skills in crafting mathematical arguments in order to demonstrate their understanding of key concepts. All performance tasks are designed so students must explain their work and mathematical thinking.

Analytical Scoring

Analytical scoring guidelines accompany each performance task, and points are awarded both for the clarity of reasoning (mathematical argumentation) and for arriving at the correct answer (computation).
Sample Performance Task and Scoring Guidelines

Arithmetic Sequences and Linear Functions

Janice wants to play soccer in the fall and her coach wants all players to complete a workout regimen for the summer. She needs to consistently increase the pounds that she can bench press. The coach told Janice to add only 10 pounds to the bar each week. Janice is relatively new to weight training, so she decides to start her bench-press routine using only the bar. The bench-press bar weighs 45 pounds.

(A) Write an equation that indicates the total number of pounds, \( p \), that Janice places on the bar at the beginning of each week, \( w \). Explain how you know that this equation represents a linear relationship.

(B) The coach says that to be eligible for the team, all players need to be able to bench press 135 pounds by the end of the 10-week summer. If Janice follows her coach's program all summer, will she be eligible for the team? Justify your response.

(C) Janice's friend Amber is also working out all summer. Amber tried to keep a workout log of the total weight she has been bench pressing, but some weeks she forgot to write down the amount. The table below shows the information that Amber wrote down.

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>100</td>
<td>115</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If Amber followed a consistent pattern for the entire summer, how much weight did she lift in weeks 4 and 7? Explain your answer.

(D) Suppose that Janice and Amber began working out in the same week. Who will be lifting more weight by the end of the 10-week summer? Show all your work and explain your answer.
These scoring guidelines are representative of the depth and kind of scoring information provided for each performance task. The format of scoring guidelines may vary.

<table>
<thead>
<tr>
<th>Part</th>
<th>Points Possible</th>
<th>Answer Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>3 points — The response includes a correct equation for the relationship, taking into account that the first week ((w = 1)) should correspond to 45 pounds. The response also correctly references a constant rate of change.</td>
<td>A correct equation is (p = 45 + 10(w - 1)). The equation could be simplified to (p = 35 + 10w). This is a linear relationship because there is a constant rate of change.</td>
</tr>
<tr>
<td></td>
<td>2 points — The response correctly references a constant rate of change but includes an incorrect equation, perhaps not taking into account that the first week should correspond to 45 pounds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 point — The response includes a correct equation, but does not reference a constant rate of change.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 points — The response does not include reference to a constant rate of change and does not include a correct equation.</td>
<td></td>
</tr>
<tr>
<td>B.</td>
<td>3 points — The response includes a correct calculation and a correct explanation that Janice will be eligible for the team.</td>
<td>If Janice follows the coach's program, she will be bench pressing (p = 45 + 10(10 - 1) = 135) pounds. Therefore, she will be eligible for the team at the end of the summer.</td>
</tr>
<tr>
<td></td>
<td>2 points — The response includes an incorrect calculation, but the student still offers a correct explanation about whether Janice would be eligible for the team.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 point — The response includes a correct calculation, but does not include a correct explanation about whether Janice would be eligible for the team.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 points — The response includes an incorrect calculation and an incorrect conclusion, or omits a conclusion about Janice's eligibility.</td>
<td></td>
</tr>
<tr>
<td>Part</td>
<td>Points Possible</td>
<td>Answer Guidance</td>
</tr>
<tr>
<td>------</td>
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</tr>
<tr>
<td>C.</td>
<td><strong>3 points</strong>—The response correctly references the constant rate of change and correctly calculates Amber's bench-press weight for weeks 4 and 7.</td>
<td>Using an understanding of arithmetic sequences, students should identify that the rate of change is 5 pounds per week. This means that in week 4 Amber lifts 105 pounds and in week 7 she lifts 120 pounds.</td>
</tr>
<tr>
<td></td>
<td><strong>2 points</strong>—The response correctly references the constant rate of change but miscalculates Amber's bench-press weight for weeks 4 and/or 7.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>1 point</strong>—The response correctly calculates Amber's bench-press weight for weeks 4 and 7, but does not reference a constant rate of change or offer any other explanation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>0 points</strong>—The response miscalculates Amber's bench-press weight for weeks 4 and 7 and does not reference a constant rate of change or offer any other explanation.</td>
<td></td>
</tr>
<tr>
<td>D.</td>
<td><strong>3 points</strong>—The response correctly extends the sequence of Amber's bench-press weight and compares it to Janice's bench-press weight in week 10. The response correctly concludes that the girls will lift the same amount by the end of the summer.</td>
<td>Very sophisticated students may construct an equation to model the amount of weight that Amber places on the bar at the beginning of week w. The question is phrased to suggest that one girl lifts more weight by week 10, but they both have 135 pounds on the bar by the end of the summer.</td>
</tr>
<tr>
<td></td>
<td><strong>2 points</strong>—The response incorrectly extends the sequence of Amber's bench-press weight and/or uses an incorrect calculation from part B to make a correct conclusion based on the available evidence.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>1 point</strong>—The response includes a correct conclusion that the girls will lift the same weight by the end of the summer, but includes either no explanation or an explanation that is incorrect.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>0 points</strong>—The response includes an incorrect conclusion and an incorrect explanation, or omits an explanation.</td>
<td></td>
</tr>
</tbody>
</table>
Units at a Glance: Content, Structure, and Pacing

The following tables map out the structure and content for each unit, as well as suggested pacing. The tables also indicate the supporting instructional and assessment resources that are provided to teachers participating in the official Pre-AP Program. Lesson sets are designed to be used alongside the teacher's existing classroom resources, textbook, and local curriculum.

### Unit 1: Linear Equations and Linear Functions

*Suggested pacing: 9 weeks*

<table>
<thead>
<tr>
<th>Key Concepts</th>
<th>Pre-AP Instructional Resources</th>
<th>Pre-AP Classroom Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Variation</td>
<td>Lesson Set provided</td>
<td></td>
</tr>
<tr>
<td>Slope and Rate of Change</td>
<td>Lesson Set provided</td>
<td></td>
</tr>
<tr>
<td>Linear Functions</td>
<td>Lesson Set provided</td>
<td>Digital Quiz 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Assessment Practice Opportunity</td>
</tr>
<tr>
<td>Linear Equations</td>
<td>Lesson Set provided for modeling with the standard form of a linear equation</td>
<td></td>
</tr>
<tr>
<td>Scatterplots and Lines of Fit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Inequalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of Unit</td>
<td></td>
<td>Digital Quiz 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Task</td>
</tr>
</tbody>
</table>

### Unit 2: Systems of Linear Equations and Inequalities

*Suggested pacing: 5 weeks*

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Graphical and Numerical Solution Techniques</td>
<td>Lesson Set provided</td>
<td></td>
</tr>
<tr>
<td>Algebraic Solution Techniques</td>
<td></td>
<td>Digital Quiz 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Assessment Practice Opportunity</td>
</tr>
<tr>
<td>Systems of Linear Inequalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modeling with Systems of Equations and Inequalities</td>
<td>Lesson Set provided for Modeling with Systems of Inequalities</td>
<td></td>
</tr>
<tr>
<td>End of Unit</td>
<td></td>
<td>Digital Quiz 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Task</td>
</tr>
</tbody>
</table>
### Unit 3: Quadratic Functions

**Suggested Pacing:** 9 weeks

<table>
<thead>
<tr>
<th>Key Concepts</th>
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<th>Pre-AP Classroom Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeling with Quadratic Functions</td>
<td>Lesson Set provided</td>
<td></td>
</tr>
<tr>
<td>Algebraic Forms of a Quadratic Function</td>
<td>Lesson Set provided</td>
<td>Digital Quiz 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Assessment Practice Opportunity</td>
</tr>
<tr>
<td>The Graph of a Quadratic Function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solving Quadratic Equations</td>
<td>Lesson Set provided for the factored form of a quadratic function</td>
<td></td>
</tr>
<tr>
<td>End of Unit</td>
<td></td>
<td>Digital Quiz 2</td>
</tr>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

### Unit 4: Exponent Properties and Exponential Functions

**Suggested Pacing:** 5 weeks

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Exponent Rules and Properties</td>
<td></td>
<td>Digital Quiz 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance Assessment Practice Opportunity</td>
</tr>
<tr>
<td>Roots of Real Numbers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exponential Growth and Decay</td>
<td>Lesson Set provided</td>
<td></td>
</tr>
<tr>
<td>End of Unit</td>
<td></td>
<td>Digital Quiz 2</td>
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<td>Performance Task</td>
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</table>
The summer before their first year teaching a Pre-AP course, instructors are encouraged to participate in Pre-AP Course Teacher Institutes. For schools participating in the 2018–19 cohort, all course teachers must participate in the professional learning institute. The four-day institute held in the summer introduces the Pre-AP course frameworks, instructional units, pedagogical principles, and assessment resources. Through the intensive and immersive study of both their specific course materials and shared cross-disciplinary principles, teachers will begin to develop their Pre-AP instructional plans for the year.

During the school year, teachers will also receive an additional five to eight hours of online training in assessment analysis and scoring of student work.

Pre-AP School Coordinators will register all teachers for their assigned Pre-AP Course Teacher Institute and communicate the details and logistics of the event to their teams.
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