

**BIG IDEAS**  
**MATH.**<sup>®</sup>  
**Algebra 1**  
A Common Core Curriculum

Ron Larson and Laurie Boswell



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# Authors



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*Laurie Boswell*

Dr. Ron Larson and Dr. Laurie Boswell began writing together in 1992. Since that time, they have authored over four dozen textbooks. This successful collaboration allows for one voice from Kindergarten through Algebra 2.

# For the Student

Welcome to *Big Ideas Math Algebra 1*. From start to finish, this program was designed with you, the learner, in mind.

As you work through the chapters in your Algebra 1 course, you will be encouraged to think and to make conjectures while you persevere through challenging problems and exercises. You will make errors—and that is ok! Learning and understanding occur when you make errors and push through mental roadblocks to comprehend and solve new and challenging problems.

In this program, you will also be required to explain your thinking and your analysis of diverse problems and exercises. Being actively involved in learning will help you develop mathematical reasoning and use it to solve math problems and work through other everyday challenges.

We wish you the best of luck as you explore Algebra 1. We are excited to be a part of your preparation for the challenges you will face in the remainder of your high school career and beyond.

## 8 Graphing Quadratic Functions

8.1 Graphing  $f(x) = ax^2$   
 8.2 Graphing  $f(x) = ax^2 + c$   
 8.3 Graphing  $f(x) = ax^2 + bx + c$   
 8.4 Graphing  $f(x) = a(x-h)^2 + k$   
 8.5 Using Intercept Form  
 8.6 Comparing Linear, Exponential, and Quadratic Functions

**Chapter Learning Target:** Understand graphing quadratic functions.  
**Chapter Success Criteria:**  
 I can identify characteristics of quadratic functions.  
 I can describe how to graph quadratic functions in different forms.  
 I can use intercept form to find areas of figures.  
 I can choose an appropriate function to model data.

**SEE THE BIG IDEAS**

Town Population (p. 464)  
 Roller Coaster (p. 448)  
 Garden Waterfalls (p. 430)  
 Satellite Dish (p. 437)  
 Firework Explosion (p. 437)

### Maintaining Mathematical Proficiency

#### Graphing Linear Equations

**Example 1** Graph  $y = -x - 1$ .

**Step 1** Make a table of values.

x	y = -x - 1	y	(x, y)
-1	y = -(-1) - 1	0	(-1, 0)
0	y = -(0) - 1	-1	(0, -1)
1	y = -(1) - 1	-2	(1, -2)
2	y = -(2) - 1	-3	(2, -3)

**Step 2** Plot the ordered pairs.

**Step 3** Draw a line through the points.

**Graph the linear equation.**

1.  $y = 2x - 3$       2.  $y = -3x + 4$   
 3.  $y = -\frac{1}{2}x - 2$       4.  $y = x + 5$

**Evaluating Expressions**

**Example 2** Evaluate  $2x^2 + 3x - 5$  when  $x = -1$ .

### Mathematical Practices

Mathematically proficient students try special cases of the original problem to gain insight into its solution.

#### Problem-Solving Strategies

**Core Concept**

**Trying Special Cases**

When solving a problem in mathematics, it can be helpful to try special cases of the original problem. For instance, in this chapter, you will learn to graph a quadratic function of the form  $f(x) = ax^2 + bx + c$ . The problem-solving strategy used to solve graph quadratic functions of the form  $f(x) = ax^2$ . From there, you progress to other forms of quadratic functions.

$f(x) = ax^2$       Section 8.1  
 $f(x) = ax^2 + c$       Section 8.2  
 $f(x) = ax^2 + bx + c$       Section 8.3  
 $f(x) = a(x-h)^2 + k$       Section 8.4

**EXAMPLE 1** Graphing the Parent Quadratic Function

Graph the parent quadratic function  $y = x^2$ . Then describe its graph.

**SOLUTION**

The function is of the form  $y = ax^2$ , where  $a = 1$ . By plotting several points, you can see that the graph is U-shaped, as shown.

## 8.1 Graphing $f(x) = ax^2$

### Essential Question

What are some of the characteristics of the graph of a quadratic function of the form  $f(x) = ax^2$ ?

**EXPLORATION 1** Graphing Quadratic Functions

Work with a partner. Graph each quadratic function. Compare each graph to the graph of  $f(x) = x^2$ .

a.  $g(x) = 2x^2$       b.  $g(x) = -5x^2$

c.  $g(x) = -0.2x^2$       d.  $g(x) = \frac{1}{3}x^2$

**REASONING QUANTITATIVELY**

To be proficient in math, you need to make sense of quantities and their relationships in problem situations.

**Communicate Your Answer**

2. What are some of the characteristics of the graph of a quadratic function of the form  $f(x) = ax^2$ ?

3. How does the value of  $a$  affect the graph of  $f(x) = ax^2$ ? Consider  $0 < a < 1$ ,  $a > 1$ ,  $-1 < a < 0$ , and  $a < -1$ . Use a graphing calculator to verify your answers.

4. The figure shows the graph of a quadratic function of the form  $y = ax^2$ . Which of the intervals in Question 3 describes the value of  $a$ ? Explain your reasoning.

Section 8.1 Graphing  $f(x) = ax^2$  419

**STUDY TIP**

To make the calculations easier, choose values that are multiples of 3.

**EXAMPLE 3** Graphing  $y = ax^2$  When  $a < 0$

Graph  $h(x) = -\frac{1}{3}x^2$ . Compare the graph to the graph of  $f(x) = x^2$ .

**SOLUTION**

**Step 1** Make a table of values.

x	-6	-3	0	3	6
$h(x)$	-12	-3	0	-3	-12

**Step 2** Plot the ordered pairs.

**Step 3** Draw a smooth curve through the points.

The graph has the same vertex, (0, 0), and the same axis of symmetry,  $x = 0$ , but the graph of  $h$  opens down and is wider than the graph of  $f$ . So, the graph of  $h$  is a vertical stretch by a factor of  $\frac{1}{3}$  and a reflection in the  $x$ -axis of the graph of  $f$ .

**Monitoring Progress** Help in English and Spanish at [BigIdeasMath.com](#)

Graph the functions. Compare the graph to the graph of  $f(x) = x^2$ .

3.  $g(x) = 2x^2$       4.  $h(x) = \frac{1}{2}x^2$       5.  $m(x) = \frac{1}{4}x^2$   
 6.  $p(x) = -3x^2$       7.  $q(x) = -0.1x^2$       8.  $r(x) = -\frac{1}{5}x^2$

**EXAMPLE 4** Solving a Real-Life Problem

The diagram at the left shows the cross section of a satellite dish, where  $x$  and  $y$  are measured in meters. Find the width and depth of the dish.

**SOLUTION**

Use the domain of the function to find the width of the dish. Use the range to find the depth.

The leftmost point on the graph is (-2, 1), and the rightmost point is (2, 1). So, the domain is  $-2 \leq x \leq 2$ , which represents 4 meters.

The lowest point on the graph is (0, 0), and the highest points on the graph are (-2, 1) and (2, 1). So, the range is  $0 \leq y \leq 1$ , which represents 1 meter.

So, the satellite dish is 4 meters wide and 1 meter deep.

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9. The cross section of a spotlight can be modeled by the graph of  $y = 0.5x^2$ , where  $x$  and  $y$  are measured in inches and  $-2 \leq x \leq 2$ . Find the width and depth of the spotlight.

## 8.1 Exercises

Dynamic Solutions available at [BigIdeasMath.com](#)

**Vocabulary and Core Concept Check**

1. **VOCABULARY** What is the U-shaped graph of a quadratic function called?  
 2. **WRITING** When does the graph of a quadratic function open up? open down?

**Monitoring Progress and Modeling with Mathematics**

In Exercises 3 and 4, identify characteristics of the quadratic function and its graph. (See Example 2.)

3.

4.

In Exercises 5–12, graph the function. Compare the graph to the graph of  $f(x) = x^2$ . (See Examples 2 and 3.)

5.  $h(x) = 6x^2$       6.  $h(x) = 2.5x^2$   
 7.  $h(x) = \frac{1}{2}x^2$       8.  $h(x) = 0.75x^2$   
 9.  $m(x) = -2x^2$       10.  $g(x) = -\frac{1}{3}x^2$   
 11.  $h(x) = -0.2x^2$       12.  $g(x) = -\frac{1}{5}x^2$

In Exercises 13–16, use a graphing calculator to graph the function. Compare the graph to the graph of  $y = -4x^2$ .

13.  $y = -4x^2$       14.  $y = -0.4x^2$   
 15.  $y = -0.04x^2$       16.  $y = -0.04x^2$

**17. ERROR ANALYSIS** Describe and correct the error in graphing and comparing  $y = x^2$  and  $y = 0.5x^2$ .

**18. MODELING WITH MATHEMATICS** The arch support of a bridge can be modeled by  $y = -0.0002x^2$ , where  $x$  and  $y$  are measured in feet. Find the height and width of the arch. (See Example 4.)

**19. PROBLEM SOLVING** The breaking strength  $S$  (in pounds) of a certain rope can be modeled by  $S = 8900d^2$ , where  $d$  is the diameter (in inches) of the rope.

a. Describe the domain and range of the function.  
 b. Graph the function using the domain in part (a).  
 c. A multi-rope has four times the breaking strength of another multi-rope. Does the stronger rope have four times the diameter? Explain.

# Big Ideas Math High School Research

*Big Ideas Math Algebra 1, Geometry, and Algebra 2* is a research-based program providing a rigorous, focused, and coherent curriculum for high school students. Ron Larson and Laurie Boswell utilized their expertise as well as the body of knowledge collected by additional expert mathematicians and researchers to develop each course.

The pedagogical approach to this program follows the best practices outlined in the most prominent and widely-accepted educational research and standards, including:

Achieve, ACT, and The College Board

*Adding It Up: Helping Children Learn Mathematics,*

National Research Council ©2001

Common Core State Standards for Mathematics, National Governors Association Center for Best Practices and the Council of Chief State School Officers ©2010

Curriculum Focal Points and the *Principles and Standards for School Mathematics* ©2000, National Council of Teachers of Mathematics (NCTM)

Project Based Learning,  
The Buck Institute

Rigor/Relevance Framework™,  
International Center for Leadership in Education

*Universal Design for Learning Guidelines,*  
CAST ©2011

*Unlocking Formative Assessment: Practical Strategies for Enhancing Students' Learning in the Primary and Intermediate Classroom,*  
Shirley Clarke, Helen Timperley, and John Hattie ©2004

*Evaluating the Quality of Learning: The SOLO Taxonomy,*  
John B. Biggs and Kevin F. Collis ©1982

*Formative Assessment in the Secondary Classroom,*  
Shirley Clarke ©2005

*Improving Student Achievement: A Practical Guide to Assessment for Learning,*  
Toni Glasson ©2009

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# Common Core State Standards for Mathematical Practice

## **Make sense of problems and persevere in solving them.**

- *Essential Questions* help students focus on core concepts as they analyze and work through each *Exploration*.
- Section opening *Explorations* allow students to struggle with new mathematical concepts and explain their reasoning in the *Communicate Your Answer* questions.

## **Reason abstractly and quantitatively.**

- *Reasoning, Critical Thinking, Abstract Reasoning, and Problem Solving* exercises challenge students to apply their acquired knowledge and reasoning skills to solve each problem.
- *Thought Provoking* exercises test the reasoning skills of students as they analyze and interpret perplexing scenarios.

## **Construct viable arguments and critique the reasoning of others.**

- Students must justify their responses to each *Essential Question* in the *Communicate Your Answer* questions at the end of each *Exploration* set.
- Students are asked to construct arguments and critique the reasoning of others in specialized exercises, including *Making an Argument, How Do You See It?, Drawing Conclusions, Reasoning, Error Analysis, Problem Solving, and Writing*.

## **Model with mathematics.**

- Real-life scenarios are utilized in *Explorations, Examples, Exercises, and Assessments* so students have opportunities to apply the mathematical concepts they have learned to realistic situations.
- *Modeling with Mathematics* exercises allow students to interpret a problem in the context of a real-life situation, often utilizing tables, graphs, visual representations, and formulas.

## **Use appropriate tools strategically.**

- Students are provided opportunities for selecting and utilizing the appropriate mathematical tool in *Using Tools* exercises. Students work with graphing calculators, dynamic geometry software, models, and more.
- A variety of tool papers and manipulatives are available for students to use in problems as strategically appropriate.

## **Attend to precision.**

- *Vocabulary and Core Concept Check* exercises require students to use clear, precise mathematical language in their solutions and explanations.
- The many opportunities for cooperative learning in this program, including working with partners for each *Exploration*, support precise, explicit mathematical communication.

## **Look for and make use of structure.**

- *Using Structure* exercises provide students with the opportunity to explore patterns and structure in mathematics.
- Students analyze structure in problems through *Justifying Steps* and *Analyzing Equations* exercises.

## **Look for and express regularity in repeated reasoning.**

- Students are continually encouraged to evaluate the reasonableness of their solutions and their steps in the problem-solving process.
- Stepped-out *Examples* encourage students to maintain oversight of their problem-solving process and pay attention to the relevant details in each step.

# Common Core State Standards for Mathematical Content for Algebra 1

Chapter Coverage for Standards



## Conceptual Category Number and Quantity

- The Real Number System
- Quantities



## Conceptual Category Algebra

- Seeing Structure in Expressions
- Arithmetic with Polynomials and Rational Expressions
- Creating Equations
- Reasoning with Equations and Inequalities



## Conceptual Category Functions

- Interpreting Functions
- Building Functions
- Linear, Quadratic, and Exponential Models



## Conceptual Category Statistics and Probability

- Interpreting Categorical and Quantitative Data

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### See the Big Idea

Learn how boat navigators use dead reckoning to calculate their distance covered in a single direction.





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### See the Big Idea

Determine how designers decide on the number of electrical circuits needed in a house.



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### See the Big Idea

Discover why unlike almost any other natural phenomenon, light travels at a constant speed.



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### See the Big Idea

Explore wind power and discover where the future of wind power will take us.



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**See the Big Idea**  
Learn how fisheries manage their complex ecosystems.



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### See the Big Idea

Explore the variety of recursive sequences in language, art, music, nature, and games.



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### See the Big Idea

Explore whether seagulls and crows use the optimal height while dropping hard-shelled food to crack it open.



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### See the Big Idea

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### See the Big Idea

Explore the Parthenon and investigate how the use of the golden rectangle has evolved since its discovery.





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### See the Big Idea

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# 11

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### See the Big Idea

Foray into the fashion differences between men and women.



# How to Use Your Math Book

Get ready for each chapter by **Maintaining Mathematical Proficiency** and reviewing the **Mathematical Practices**. Begin each section by working through the **EXPLORATIONS** to **Communicate Your Answer** to the **Essential Question**. Each **Lesson** will explain **What You Will Learn** through **EXAMPLES**, **Core Concepts**, and **Core Vocabulary**. Answer the **Monitoring Progress** questions as you work through each lesson. Look for **STUDY TIPS**, **COMMON ERRORS**, and suggestions for looking at a problem **ANOTHER WAY** throughout the lessons. We will also provide you with guidance for accurate mathematical **READING** and concept details you should **REMEMBER**.

Sharpen your newly acquired skills with **Exercises** at the end of every section. Halfway through each chapter you will be asked **What Did You Learn?** and you can use the Mid-Chapter **Quiz** to check your progress. You can also use the **Chapter Review** and **Chapter Test** to review and assess yourself after you have completed a chapter.

Apply what you learned in each chapter to a **Performance Task** and build your confidence for taking standardized tests with each chapter's **Cumulative Assessment**.

For extra practice in any chapter, use your *Online Resources*, *Skills Review Handbook*, or your *Student Journal*.

