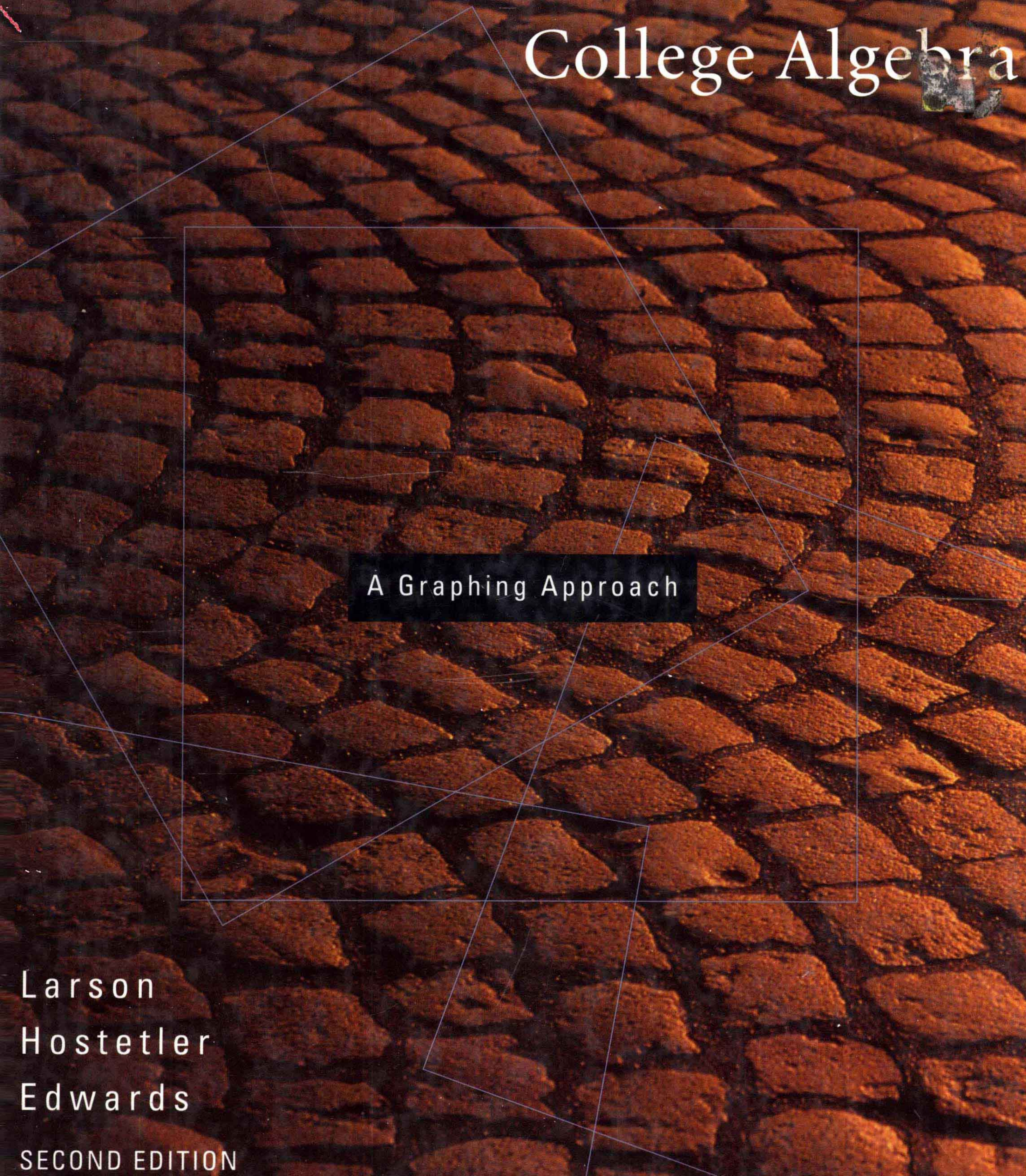

College Algebra

A Graphing Approach

Larson

Hostetler

Edwards

SECOND EDITION

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A Graphing Approach

SECOND EDITION

Roland E. Larson
The Pennsylvania State University
The Behrend College

Robert P. Hostetler
The Pennsylvania State University
The Behrend College

Bruce H. Edwards
University of Florida

WITH THE ASSISTANCE OF

David E. Heyd
The Pennsylvania State University
The Behrend College

HOUGHTON MIFFLIN COMPANY Boston New York

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College Algebra

Preface

College Algebra: A Graphing Approach, Second Edition, is the premier text for a reform-oriented course. Designed to build a strong foundation in algebra, the text encourages students to develop a firm grasp of the underlying mathematical concepts while using algebra as a tool for solving real-life problems. The comprehensive text presentation invites discovery and exploration, while the integrated technology and consistent problem-solving strategies help the student develop strong college algebra skills.

College Algebra Reform

The college algebra course has changed over the past few years in response to the growing discussion of reform in mathematics education. Generally speaking, these changes have focused on the following areas: technology, real-life applications, problem-solving, and communicating about mathematics. The Second Edition embodies the spirit of these reform ideals without compromising the mathematical integrity of the course presentation. All text elements from the previous edition were considered for revision and many new examples, exercises, and applications were added.

Technology Graphing technology is consistently incorporated throughout the Second Edition. The visualization and exploration capabilities of technology encourage the student to participate actively in the learning process, to develop their intuitive understanding of mathematical concepts, and to solve problems using actual data. Thus, students learn how algebra functions as a modeling language for real-life problems. Technology is used as a tool, drawn into the discussion whenever it offers a useful perspective on the topic at hand. For example, the power of graphing technology may be used to guide the students through thought-provoking explorations or to show alternative problem-solving techniques. Where appropriate, situations in which the results obtained through the use of technology may be misleading are also noted.

The Second Edition assumes that the student will use a graphing calculator on a daily basis in the course. Integrated throughout the text at point of use are many opportunities for investigation using technology (e.g., see page 318) and exercises that require the use of a graphing utility (e.g., see page 188). The text also carefully shows how to use graphing technology to best advantage (e.g., see page 185).

Whenever possible, references to graphing technology are generic. In a few cases, however, the text includes programs that will enable the student to investigate particular mathematical concepts (e.g., see page 134). Comparable programs for a wide variety of Texas Instruments, Casio, Sharp, and Hewlett-

Packard graphing calculators—including the most current models—are given in the appendix.

To accommodate a variety of teaching and learning styles, *College Algebra: A Graphing Approach,* Second Edition, is also available in a multimedia, CD-ROM format. *Interactive College Algebra: A Graphing Approach* offers students a variety of additional tutorial assistance, including examples and exercises with detailed solutions; pre-, post-, and self-tests with answers; and *TI-82* and *TI-83* graphing calculator emulators. (See pages xviii–xx for more detailed information.)

Real-Life Applications To emphasize for students the connection between mathematical concepts and real-world situations, up-to-date, real-life applications are integrated throughout the text. These applications appear as chapter introductions with related exercises (e.g., see pages 75 and 115), examples (e.g., see page 360), exercises (e.g., see page 87), Group Activities (e.g., see page 97), and Chapter Projects (e.g., see page 455).

Students have many opportunities to collect and interpret data, to make conjectures, and to construct mathematical models in the examples, exercises, Group Activities, and Chapter Projects. Students work on modeling problems with experimental and theoretical probabilities (e.g., see page 591), use mathematical models to make predictions or draw conclusions from real data (e.g., see page 354), compare models (e.g., see page 307), and apply curve-fitting techniques to create their own models from data (e.g., see page 230). In the process, the Second Edition gives students many more opportunities to use charts, tables, scatter plots, and graphs to summarize, analyze, and interpret data.

Problem Solving The primary goal of any mathematics textbook is to encourage students to become competent and confident problem solvers. Many aspects of this revision focused on this goal—including the addition of new features such as Chapter Projects, Explorations, and Group Activities, as well as extensive and careful revision of the examples and exercise sets. Students are asked to use numerical, graphical, and algebraic techniques, and the use of graphing technology as a problem-solving tool is encouraged as appropriate (e.g., see page 215). Throughout, students are encouraged to follow a consistent approach to solving applied problems: Construct a verbal model, label terms, construct an algebraic model, solve the problem using the model, and check the answer in the original statement of the problem.

Like the previous edition, the Second Edition has an abundance of exercises that are designed to develop skills. The text also includes many other types of exercises that offer students the opportunity to refine their problem-solving skills, such as exercises that require interpretations (e.g., see page 329), those having many correct answers (e.g., see page 288), and multipart exercises designed to lead the student through problem-solving strategies (e.g., see page 226).

Communicating about Mathematics Each section in the Second Edition ends with a Group Activity. Designed to be completed in class or as homework assignments, the Group Activities give students the opportunity to work cooperatively as they think, talk, and write about mathematics. Students' understanding is reinforced through interpretation of mathematical concepts and results (e.g., see page 250), problem posing and error analysis (e.g., see page 428), and constructing mathematical models, tables and graphs (e.g., see page 418).

Making connections between algebra and real-world situations also helps students understand the underlying theory. Other connections are emphasized in this text as well, including those to probability (e.g., see Chapter 7), geometry (e.g., see page 397), and statistics (see the Sections P.6 and 2.6).

Improved Coverage

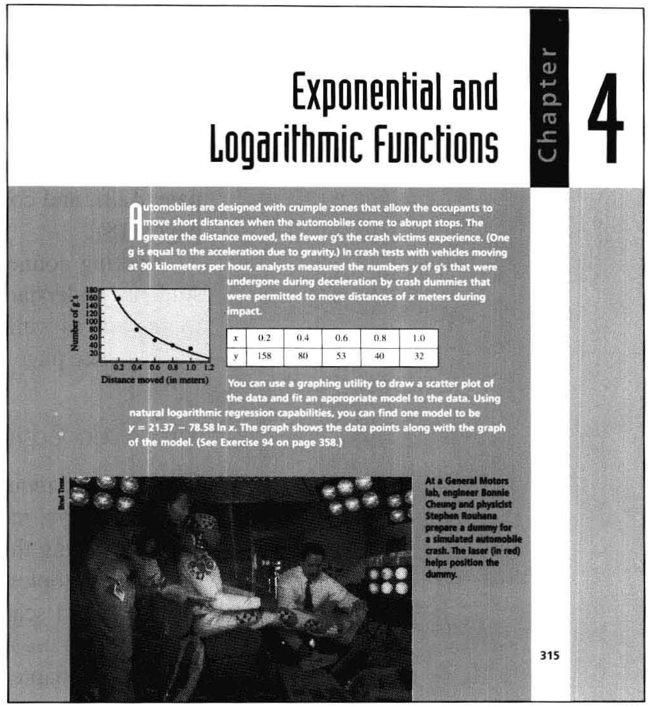
Chapter P, Prerequisites, is streamlined in the Second Edition. All or part of this review material may be covered or it may be omitted, offering greater flexibility in designing the course syllabus.

Several topics are now covered earlier in the Second Edition. Linear modeling and scatter plots are covered much earlier, in Chapter 2. Complex numbers also are now in Chapter 2. Rational functions are covered with polynomials in Chapter 3. The discussion of exponential and logarithmic functions appears a chapter earlier, in Chapter 4. Coverage of systems of equations and inequalities was moved to Chapter 5 and now includes partial fractions and linear programming.

New sections on exploring data have been added to Chapters P, 2, and 4. The coverage of matrices in Chapter 6 was expanded to include determinants of matrices and applications. Conics and translations of conics have been moved to a new chapter, Chapter 8, along with new coverage of parametric equations.

Features of the Second Edition

Chapter Opener Each chapter opens with a look at a real-life application. Real data is presented using graphical, numerical, and algebraic techniques.



Chapter 4

Exponential and Logarithmic Functions

Automobiles are designed with crumple zones that allow the occupants to move short distances when the automobiles come to abrupt stops. The greater the distance moved, the fewer g's the crash victims experience. (One g is equal to the acceleration due to gravity.) In crash tests with vehicles moving at 90 kilometers per hour, analysts measured the numbers y of g's that were undergone during deceleration by crash dummies that were permitted to move distances of x meters during impact.

x	0.2	0.4	0.6	0.8	1.0
y	158	80	53	40	32

You can use a graphing utility to draw a scatter plot of the data and fit an appropriate model to the data. Using natural logarithmic regression capabilities, you can find one model to be $y = 21.37 - 78.58 \ln x$. The graph shows the data points along with the graph of the model. (See Exercise 94 on page 358.)

At a General Motors lab, engineer Bonnie Cheung and physicist Stephen Rouhana prepare a dummy for a simulated automobile crash. The laser (in red) helps position the dummy.

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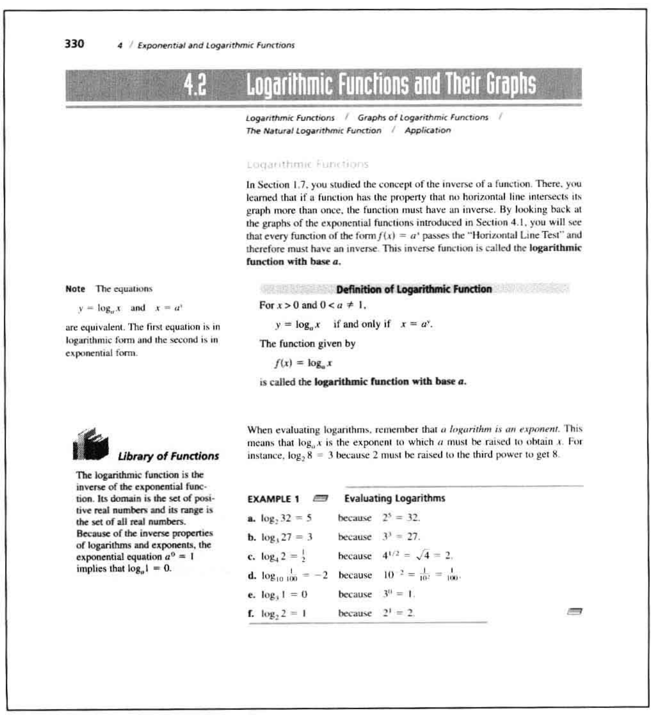
Notes Notes anticipate students' needs by offering additional insights, pointing out common errors, and describing generalizations.

Theorems, Definitions, and Guidelines All of the important rules, formulas, theorems, guidelines, properties, definitions, and summaries are highlighted for emphasis. Each is also titled for easy reference.



330 4 / *Exponential and Logarithmic Functions*

4.2 Logarithmic Functions and Their Graphs

Logarithmic Functions / Graphs of Logarithmic Functions / The Natural Logarithmic Function / Application

Logarithmic Functions

In Section 1.7, you studied the concept of the inverse of a function. There, you learned that if a function has the property that no horizontal line intersects its graph more than once, the function must have an inverse. By looking back at the graphs of the exponential functions introduced in Section 4.1, you will see that every function of the form $f(x) = a^x$ passes the "Horizontal Line Test" and therefore must have an inverse. This inverse function is called the **logarithmic function with base *a*.**

Note The equations

$y = \log_a x$ and $x = a^y$

are equivalent. The first equation is in logarithmic form and the second is in exponential form.

Definition of Logarithmic Function

For $x > 0$ and $0 < a \neq 1$,

$y = \log_a x$ if and only if $x = a^y$.

The function given by

$f(x) = \log_a x$

is called the **logarithmic function with base *a*.**

When evaluating logarithms, remember that *a logarithm is an exponent*. This means that $\log_a x$ is the exponent to which a must be raised to obtain x. For instance, $\log_2 8 = 3$ because 2 must be raised to the third power to get 8.

Library of Functions

The logarithmic function is the inverse of the exponential function. Its domain is the set of positive real numbers and its range is the set of all real numbers. Because of the inverse properties of logarithms and exponents, the exponential equation $a^0 = 1$ implies that $\log_a 1 = 0$.

EXAMPLE 1 Evaluating Logarithms

a. $\log_2 32 = 5$ because $2^5 = 32$.

b. $\log_3 27 = 3$ because $3^3 = 27$.

c. $\log_4 2 = \frac{1}{2}$ because $4^{1/2} = \sqrt{4} = 2$.

d. $\log_{10} \frac{1}{100} = -2$ because $10^{-2} = \frac{1}{10^2} = \frac{1}{100}$.

e. $\log_3 1 = 0$ because $3^0 = 1$.

f. $\log_2 2 = 1$ because $2^1 = 2$.

Section Outline Each section begins with a list of the major topics covered in the section. These topics are also the subsection titles and can be used for easy reference and review by students. In addition, an exercise application that uses a skill or illustrates a concept covered in the section is highlighted to emphasize the connection between mathematical concepts and real-life situations.

Library of Functions The concept of the function is introduced in Chapter 1. In the material that follows, the icon appears each time a new type of function is described in detail.

Intuitive Foundation for Calculus Special emphasis is given to the algebraic skills that are needed in calculus. Many examples in the Second Edition discuss algebraic techniques or graphically show concepts that are used in calculus, providing an intuitive foundation for future work.

Relative Minimum and Maximum Values

The points at which a function changes its increasing, decreasing, or constant behavior are helpful in determining the relative maximum or relative minimum values of the function.

Definition of Relative Minimum and Relative Maximum

A function value $f(a)$ is called a **relative minimum** of f if there exists an interval (x_1, x_2) that contains a such that

$$x_1 < x < x_2 \quad \text{implies} \quad f(a) \le f(x).$$

A function value $f(a)$ is called a **relative maximum** of f if there exists an interval (x_1, x_2) that contains a such that

$$x_1 < x < x_2 \quad \text{implies} \quad f(a) \ge f(x).$$

Figure 1.32

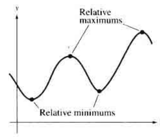


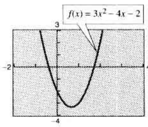
Figure 1.32 shows several different examples of relative minimums and relative maximums. In Section 3.1, you will study a technique for finding the *exact points* at which a second-degree polynomial function has a relative minimum or relative maximum. For the time being, however, you can use a graphing utility to find reasonable approximations of these points.

EXAMPLE 4 **Approximating a Relative Minimum**

Use a graphing utility to approximate the relative minimum of the function $f(x) = 3x^2 - 4x - 2$.

Solution

Figure 1.33



The graph of f is shown in Figure 1.33. By using the zoom and trace features of a graphing utility, you can estimate that the function has a relative minimum at the point

$(0.67, -3.33)$. Relative minimum

Later, in Section 3.1, you will be able to determine that the exact point at which the relative minimum occurs is $(\frac{2}{3}, -\frac{10}{3})$.

Note When you use a graphing utility to estimate x- and y-values of a relative minimum or relative maximum, the automatic zoom feature will often produce graphs that are nearly flat. To overcome this problem, you can manually change the vertical setting of the viewing rectangle. The graph will vertically stretch if the values of Ymin and Ymax are closer together.

The Remainder and Factor Theorems

The remainder obtained in the synthetic division process has an important interpretation, as described in the **Remainder Theorem.**

Think About the Proof

To prove the Remainder Theorem, you can use the Division Algorithm to write $f(x)$ as

$$f(x) = (x - k)q(x) + r(x).$$

By the Division Algorithm, you know that either $r(x) = 0$ or the degree of $r(x)$ is less than the degree of $x - k$. How does this allow you to prove the theorem? The details of the proof are given in the appendix.

The Remainder Theorem

If a polynomial $f(x)$ is divided by $x - k$, the remainder is

$$r = f(k).$$

The Remainder Theorem tells you that synthetic division can be used to evaluate a polynomial function. That is, to evaluate a polynomial function $f(x)$ when $x = k$, divide $f(x)$ by $x - k$. The remainder will be $f(k)$, as illustrated in Example 5.

EXAMPLE 5 **Using the Remainder Theorem**

Use the Remainder Theorem to evaluate the following function at $x = -2$.

$$f(x) = 3x^3 + 8x^2 + 5x - 7$$

Solution

Using synthetic division, you obtain the following.

−2	3	8	5	−7
		−6	−4	−2
	3	2	1	−9

Because the remainder is $r = -9$, you can conclude that

$$f(\ ) = -9.$$

This means that $(-2, -9)$ is a point on the graph of f. Try checking this by substituting $x = -2$ in the original function.

Think About the Proof

To prove the Factor Theorem, you can use the Division Algorithm to write $f(x)$ as

$$f(x) = (x - k)q(x) + r(x).$$

By the Remainder Theorem, you know that $r(x) = f(k)$. Thus,

$$f(x) = (x - k)q(x) + f(k)$$

where $q(x)$ is a polynomial of lesser degree than $f(x)$. How does this allow you to prove the theorem? The details of the proof are in the appendix.

Another important theorem is the **Factor Theorem,** which is stated below. This theorem states that you can test to see whether a polynomial has $(x - k)$ as a factor by evaluating the polynomial at $x = k$. If the result is 0, $(x - k)$ is a factor.

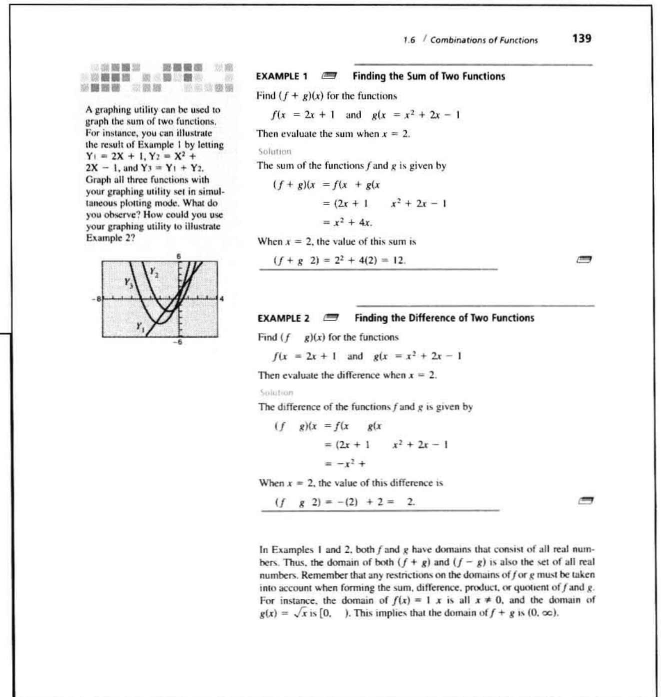
The Factor Theorem

A polynomial $f(x)$ has a factor $(x - k)$ if and only if $f(k) = 0$.

Think About the Proof Located in the margin adjacent to the corresponding theorem, each Think About the Proof feature offers strategies for proving the theorem. Detailed proofs for all theorems are given in Appendix B.

Technology Technology is integrated throughout the text at point of use as a tool for visualization, investigation, and verification. Instructions for using graphing utilities are given as necessary.

Study Tips Study Tips appear in the margin at point of use and offer students specific suggestions for studying algebra.



1.6 / Combinations of Functions 139

A graphing utility can be used to graph the sum of two functions. For instance, you can illustrate the result of Example 1 by letting Y1 = 2X + 1, Y2 = X² + 2X − 1, and Y3 = Y1 + Y2. Graph all three functions with your graphing utility set in simultaneous plotting mode. What do you observe? How could you use your graphing utility to illustrate Example 2?

EXAMPLE 1 **Finding the Sum of Two Functions**

Find $(f + g)(x)$ for the functions

$f(x) = 2x + 1$ and $g(x) = x^2 + 2x - 1$

Then evaluate the sum when $x = 2$.

Solution

The sum of the functions f and g is given by

$(f + g)(x) = f(x) + g(x) = (2x + 1) + (x^2 + 2x - 1) = x^2 + 4x.$

When $x = 2$, the value of this sum is

$(f + g)(2) = 2^2 + 4(2) = 12.$

EXAMPLE 2 **Finding the Difference of Two Functions**

Find $(f - g)(x)$ for the functions

$f(x) = 2x + 1$ and $g(x) = x^2 + 2x - 1$

Then evaluate the difference when $x = 2$.

Solution

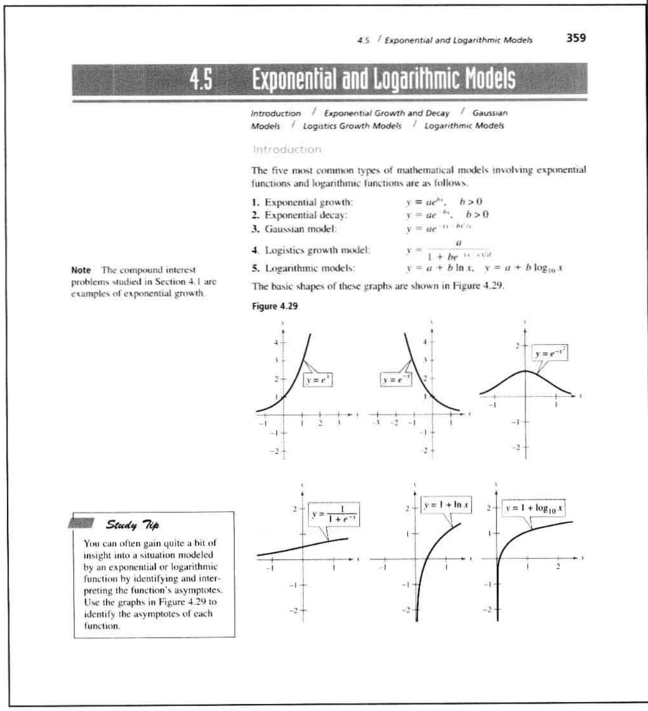
The difference of the functions f and g is given by

$(f - g)(x) = f(x) - g(x) = (2x + 1) - (x^2 + 2x - 1) = -x^2 + 2.$

When $x = 2$, the value of this difference is

$(f - g)(2) = -(2)^2 + 2 = -2.$

In Examples 1 and 2, both f and g have domains that consist of all real numbers. Thus, the domain of both $(f + g)$ and $(f - g)$ is also the set of all real numbers. Remember that any restrictions on the domains of f or g must be taken into account when forming the sum, difference, product, or quotient of f and g. For instance, the domain of $f(x) = 1/x$ is all $x \neq 0$, and the domain of $g(x) = \sqrt{x}$ is $[0, \infty)$. This implies that the domain of $f + g$ is $(0, \infty)$.



4.5 / Exponential and Logarithmic Models 359

4.5 Exponential and Logarithmic Models

Introduction / Exponential Growth and Decay / Gaussian Models / Logistics Growth Models / Logarithmic Models

Introduction

The five most common types of mathematical models involving exponential functions and logarithmic functions are as follows.

1. Exponential growth: $y = ae^{bx}$, $b > 0$
2. Exponential decay: $y = ae^{-bx}$, $b > 0$
3. Gaussian model: $y = ae^{-(x-b)^2/c}$
4. Logistics growth model: $y = \frac{a}{1 + be^{-(x-c)/d}}$
5. Logarithmic models: $y = a + b \ln x$, $y = a + b \log_{10} x$

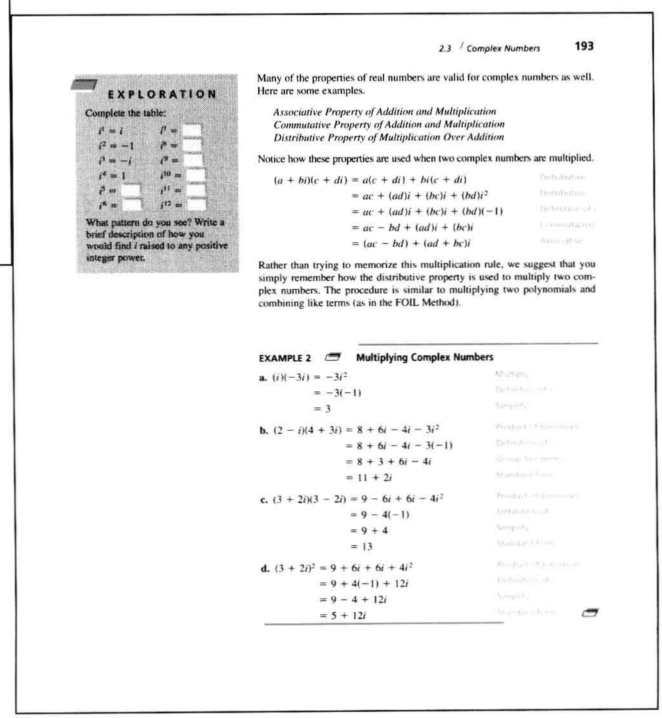
Note The compound interest problems studied in Section 4.1 are examples of exponential growth.

The basic shapes of these graphs are shown in Figure 4.29.

Figure 4.29

Study Tip

You can often gain quite a bit of insight into a situation modeled by an exponential or logarithmic function by identifying and interpreting the function's asymptotes. Use the graphs in Figure 4.29 to identify the asymptotes of each function.



2.3 / Complex Numbers 193

EXPLORATION

Complete the table:

$i^1 = i$, $i^2 = -1$, $i^3 = -i$, $i^4 = 1$, $i^5 =$ ☐, $i^6 =$ ☐, $i^7 =$ ☐, $i^8 =$ ☐, $i^9 =$ ☐, $i^{10} =$ ☐, $i^{11} =$ ☐, $i^{12} =$ ☐

What pattern do you see? Write a brief description of how you would find i raised to any positive integer power.

Many of the properties of real numbers are valid for complex numbers as well. Here are some examples.

Associative Property of Addition and Multiplication
Commutative Property of Addition and Multiplication
Distributive Property of Multiplication Over Addition

Notice how these properties are used when two complex numbers are multiplied.

$(a + bi)(c + di) = a(c + di) + bi(c + di) = ac + (ad)i + (bc)i + (bd)i^2 = ac + (ad)i + (bc)i + (bd)(-1) = ac - bd + (ad)i + (bc)i = (ac - bd) + (ad + bc)i$

Rather than trying to memorize this multiplication rule, we suggest that you simply remember how the distributive property is used to multiply two complex numbers. The procedure is similar to multiplying two polynomials and combining like terms (as in the FOIL Method).

EXAMPLE 2 **Multiplying Complex Numbers**

a. $(i)(-3i) = -3i^2 = -3(-1) = 3$

b. $(2 - i)(4 + 3i) = 8 + 6i - 4i - 3i^2 = 8 + 6i - 4i - 3(-1) = 8 + 3 + 6i - 4i = 11 + 2i$

c. $(3 + 2i)(3 - 2i) = 9 - 6i + 6i - 4i^2 = 9 - 4(-1) = 9 + 4 = 13$

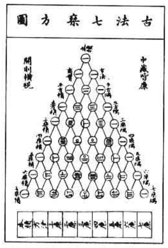
d. $(3 + 2i)^2 = 9 + 6i + 6i + 4i^2 = 9 + 4(-1) + 12i = 9 - 4 + 12i = 5 + 12i$

Exploration Throughout the text, the Exploration features encourage active participation by students, strengthening their intuition and critical thinking skills by exploring mathematical concepts and discovering mathematical relationships. Using a variety of approaches—including visualization, verification, use of graphing utilities, pattern recognition, and modeling—students are encouraged to develop a conceptual understanding of theoretical topics.

Historical Notes To help students understand that algebra has a past, historical notes featuring mathematicians and their work and mathematical artifacts are included in each chapter.

Graphics Visualization is a critical problem-solving skill. To encourage the development of this ability, the text has nearly 1500 figures in examples, exercises, and answers to exercises. Included are graphs of equations and functions, geometric figures, displays of statistical information, scatter plots, and numerous screen outputs from graphing technology. All graphs of equations and functions are computer- or calculator-generated for accuracy, and they are designed to resemble students' actual screen outputs as closely as possible. Graphics are also used to emphasize graphical interpretation, comparison, and estimation.

568 7 / *Sequences and Probability*



"Pascal's" Triangle and forms of the Binomial Theorem were known in Eastern cultures prior to the Western "discovery" of the theorem. A Chinese text *Precious Mirror* contains a triangle of binomial expansions through the eighth power.

Binomial Expansions

As mentioned at the beginning of this section, when you write out the coefficients for a binomial that is raised to a power, you are **expanding a binomial.** The formulas for binomial coefficients give you an easy way to expand binomials, as demonstrated in the next three examples.

EXAMPLE 4 Expanding a Binomial

Write the expansion for the expression

$(x+1)^3.$

Solution

The binomial coefficients from the third row of Pascal's Triangle are

1, 3, 3, 1.

Therefore, the expansion is as follows.

$$(x+1)^3 = (1)x^3 + (3)x^2(1) + (3)x(1^2) + (1)(1^3)$$
$$= x^3 + 3x^2 + 3x + 1$$

To expand binomials representing *differences*, rather than sums, you alternate signs. Here are two examples.

$$(x-1)^3 = x^3 - 3x^2 + 3x - 1$$
$$(x-1)^4 = x^4 - 4x^3 + 6x^2 - 4x + 1$$

EXAMPLE 5 Expanding a Binomial

Write the expansion for the expression

$(x-3)^4.$

Solution

The binomial coefficients from the fourth row of Pascal's Triangle are

1, 4, 6, 4, 1.

Therefore, the expansion is as follows.

$$(x-3)^4 = (1)x^4 - (4)x^3(3) + (6)x^2(3^2) - (4)x(3^3) + (1)(3^4)$$
$$= x^4 - 12x^3 + 54x^2 - 108x + 81$$

1.2 / *Lines in the Plane* 91

EXAMPLE 3 A Linear Model for Sales Prediction

During 1993, L. L. Bean's net sales were \$870 million, and in 1994 net sales were \$975 million. (Source: L. L. Bean)

a. Write a linear equation giving the net sales y in terms of the year x.

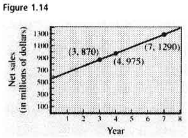
b. Use the equation to estimate the net sales during 1997.

Solution

a. Let $x = 3$ represent 1993. In Figure 1.14, let (3, 870) and (4, 975) be two points on the line representing the net sales. The slope of the line passing through these two points is

$$m = \frac{975-870}{4-3} = 105.$$

Figure 1.14

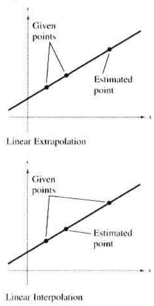


By the point-slope form, the equation of the line is as follows.

$$y - y_1 = m(x - x_1)$$
$$y - 870 = 105(x - 3)$$
$$y = 105x - 315 + 870$$
$$y = 105x + 555$$

b. Using the equation from part (a), estimate the 1997 net sales ($x = 7$) to be $y = 105(7) + 555 = 735 + 555 = \$1290$ million or \$1.29 billion.

Figure 1.15



The approximation method illustrated in Example 3 is **linear extrapolation.** Note in Figure 1.15 that for linear extrapolation, the estimated point lies outside of the given points. When the estimated point lies *between* two given points, the procedure is called **linear interpolation.**

Applications Real-life applications are integrated throughout the text in examples and exercises. These applications offer students constant review of problem-solving skills, and they emphasize the relevance of the mathematics. Many of the applications use recent, real data, and all are titled for easy reference. Photographs with captions in the introduction to the chapter also encourage students to see the link between mathematics and real life.

Examples Each of the more than 400 text examples was carefully chosen to illustrate a particular mathematical concept, problem-solving approach, or computational technique, and to enhance students' understanding. The examples in the text cover a wide variety of problem types, including theoretical problems, real-life applications (many with real data), and problems requiring the use of graphing technology. Each example is titled for easy reference, and real-life applications are labeled. Many examples include side comments in color that clarify the steps of the solution.

Problem Solving The text provides ample opportunity for students to hone their problem-solving skills. In both the exercises and the examples in the Second Edition, students are asked to apply verbal, analytical, graphical, and numerical approaches to problem solving. Students are also encouraged to use a graphing utility as a tool for solving problems. Students are taught the following approach to solving applied problems: (1) construct a verbal model; (2) label variable and constant terms; (3) construct an algebraic model; (4) using the model, solve the problem; and (5) check the answer in the original statement of the problem.

390 *5 / Systems of Equations and Inequalities*

Real Life

EXAMPLE 2 Solving a System by Substitution

A total of $12,000 is invested in two funds paying 9% and 11% simple interest. The yearly interest is $1180. How much is invested at each rate?

Solution

Verbal Model: 9% fund + 11% fund = Total investment

9% interest + 11% interest = Total interest

Labels: Amount in 9% fund $= x$ (dollars)
Interest for 9% fund $= 0.09x$ (dollars)
Amount in 11% fund $= y$ (dollars)
Interest for 11% fund $= 0.11y$ (dollars)
Total investment = $12,000 (dollars)
Total interest = $1180 (dollars)

System: $x + y = 12{,}000$ Equation 1
$0.09x + 0.11y = 1180$ Equation 2

To begin, it is convenient to multiply both sides of Equation 2 by 100 to obtain $9x + 11y = 118{,}000$. This eliminates the need to work with decimals.

$9x + 11y = 118{,}000$ Revised Equation 2

To solve this system, you can solve for x in Equation 1.

$x = 12{,}000 - y$ Revised Equation 1

Next, substitute this expression for x into Revised Equation 2 and solve the resulting equation for y.

$9x + 11y = 118{,}000$ Revised Equation 2
$9(12{,}000 - y) + 11y = 118{,}000$ Substitute $12{,}000 - y$ for x
$108{,}000 - 9y + 11y = 118{,}000$ Distributive Property
$2y = 10{,}000$ Combine like terms
$y = 5000$ Amount in 11% fund

Finally, back-substitute the value $y = 5000$ to solve for x.

$x = 12{,}000 - y$ Revised Equation 1
$x = 12{,}000 - 5000$ Substitute 5000 for y
$x = 7000$ Amount in 9% fund

The solution is (7000, 5000). Check this in the original problem.

The *Interactive* CD-ROM offers graphing utility emulators of the *TI-82* and *TI-83*, which can be used with the Examples, Explorations, Technology notes, and Exercises.

One way to check the answers you obtain in this section is to use a graphing utility. For instance, enter the two equations in Example 2

$$y_1 = 12{,}000 - x$$
$$y_2 = \frac{1180 - 0.09x}{0.11}$$

and find an appropriate viewing rectangle that shows where the lines intersect. Then use the zoom and trace features to find their point of intersection. Does this point agree with the solution obtained at the right?

4.5 / Exponential and Logarithmic Models 365

Logarithmic Models

Real Life

EXAMPLE 6 Magnitudes of Earthquakes

On the Richter scale, the magnitude R of an earthquake of intensity I is given by

$$R = \log_{10} \frac{I}{I_0}$$

where $I_0 = 1$ is the minimum intensity used for comparison. Find the intensities per unit of area for the following earthquakes. (Intensity is a measure of the wave energy of the earthquake.)

a. Tokyo and Yokohama, Japan, in 1923, $R = 8.3$

b. Kobe, Japan, in 1995, $R = 7.2$

Solution

a. Because $I_0 = 1$ and $R = 8.3$, you have

$$8.3 = \log_{10} I$$
$$I = 10^{8.3} \approx 199{,}526{,}000.$$

b. For $R = 7.2$, you have $7.2 = \log_{10} I$, and $I = 10^{7.2} \approx 15{,}849{,}000$.

Note that an increase of 1.1 units on the Richter scale (from 7.2 to 8.3) represents an intensity change by a factor of

$$\frac{199{,}526{,}000}{15{,}849{,}000} \approx 13.$$

In other words, the earthquake in 1923 had a magnitude about 13 times greater than that of the 1995 quake.

Group Activity ***Identifying Appropriate Models***

Decide for each data set which model from this section would provide the best fit. Discuss your reasoning with others in your group.

Data Set A: (18.4, 1.07), (19, 1.21), (20, 1.45), (22, 1.85), (23.5, 1.99), (25, 1.96), (26.3, 1.80), (27, 1.67), (29.7, 1.04), (31, 0.75)

Data Set B: (1.5, 11.03), (2, 12.47), (3.5, 15.26), (5, 17.05), (7.8, 19.27), (9, 19.99), (10.2, 20.61), (13.6, 22.05), (19.3, 23.80), (27, 25.48)

CD-ROM The icon refers to additional features of *Interactive College Algebra: A Graphing Approach* that enhance the text presentation, such as exercises, computer animations, examples, tests, and graphing calculator emulators.

Group Activities The Group Activities that appear at the ends of sections reinforce students' understanding by studying mathematical concepts in a variety of ways, including talking and writing about mathematics, creating and solving problems, analyzing errors, and developing and using mathematical models. Designed to be completed as group projects in class or as homework assignments, the Group Activities give students opportunities to do interactive learning and to think, talk, and write about mathematics.

Exercises The exercise sets were completely revised for the Second Edition. More than 5000 exercises with a broad range of conceptual, computational, and applied problems accommodate a variety of teaching and learning styles. Included in the section and review exercise sets are multipart, writing, and more challenging problems with extensive graphics that encourage exploration and discovery, enhance students' skills in mathematical modeling, estimation, and data interpretation and analysis, and encourage the use of graphing technology for conceptual understanding. Applications are labeled for easy reference. The exercise sets are designed to build competence, skill, and understanding; each exercise set is graded in difficulty to allow students to gain confidence as they progress. Detailed solutions to all odd-numbered exercises are given in the *Study and Solutions Guide;* answers to all odd-numbered exercises appear in the back of the text.

4.2 / Logarithmic Functions and Their Graphs **337**

4.2 /// EXERCISES

In Exercises 1–8, write the logarithmic equation in exponential form. For example, the exponential form of $\log_5 25 = 2$ is $5^2 = 25$.

1. $\log_4 64 = 3$
2. $\log_3 81 = 4$
3. $\log_7 \frac{1}{49} = -2$
4. $\log_{10} \frac{1}{1000} = -3$
5. $\log_{32} 4 = \frac{2}{5}$
6. $\log_{16} 8 = \frac{3}{4}$
7. $\ln 1 = 0$
8. $\ln 4 = 1.386 \ldots$

In Exercises 9–18, write the exponential equation in logarithmic form.

9. $5^3 = 125$
10. $8^2 = 64$
11. $81^{1/4} = 3$
12. $9^{3/2} = 27$
13. $6^{-2} = \frac{1}{36}$
14. $10^{-3} = 0.001$
15. $e^3 = 20.0855 \ldots$
16. $e^0 = 1$
17. $e^x = 4$
18. $u^v = w$

In Exercises 19–30, evaluate the expression without using a calculator.

19. $\log_2 16$
20. $\log_2(\frac{1}{8})$
21. $\log_{16} 4$
22. $\log_{27} 9$
23. $\log_7 1$
24. $\log_{10} 1000$
25. $\log_{10} 0.01$
26. $\log_{10} 10$
27. $\ln e^3$
28. $\ln 1$
29. $\log_a a^2$
30. $\log_a \frac{1}{a}$

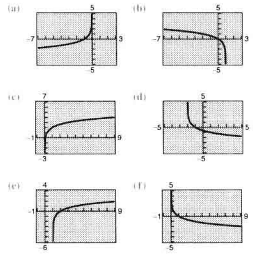
In Exercises 31–40, use a calculator to evaluate the logarithm. Round to three decimal places.

31. $\log_{10} 345$
32. $\log_{10}(\frac{4}{5})$
33. $\log_{10} 145$
34. $\log_{10} 12.5$
35. $\ln 18.42$
36. $\ln\sqrt{42}$
37. $\ln(1 + \sqrt{3})$
38. $\ln(\sqrt{5} - 2)$
39. $\ln 0.32$
40. $\ln 0.75$

In Exercises 41–44, describe the relationship between the graphs of f and g. What is the relationship between the functions f and g?

41. $f(x) = 3^x$, $g(x) = \log_3 x$
42. $f(x) = 5^x$, $g(x) = \log_5 x$
43. $f(x) = e^x$, $g(x) = \ln x$
44. $f(x) = 10^x$, $g(x) = \log_{10} x$

In Exercises 45–50, use the graph of $y = \log_3 x$ to match the given function with its graph. [The graphs are labeled (a), (b), (c), (d), (e), and (f).]



45. $f(x) = \log_3 x + 2$
46. $f(x) = -\log_3 x$
47. $f(x) = -\log_3(x + 2)$
48. $f(x) = \log_3(x - 1)$
49. $f(x) = \log_3(1 - x)$
50. $f(x) = -\log_3(-x)$

2.4 / Solving Equations Algebraically **215**

Exploration In Exercises 111 and 112, find x such that the distance between the points is 13.

111. $(1, 2), (x, -10)$
112. $(-8, 0), (x, 5)$

113. *Oxygen Consumption* The metabolic rate of ectothermic organisms increases with increasing temperature within a certain range. Experimental data for oxygen consumption (microliters per gram per hour) of a beetle for certain temperatures yielded the model

$$C = 0.45x^2 - 1.65x + 50.75, \quad 10 \le x \le 25$$

where x is the air temperature in degrees Celsius.

(a) Use a graphing utility to graph the consumption function over the specified domain.

(b) Use the graph to approximate the air temperature resulting in oxygen consumption of 150 microliters per gram per hour.

(c) If the temperature is increased from 10 to 20 degrees, the oxygen consumption is increased by approximately what factor?

114. *Saturated Steam* The temperature T (in degrees Fahrenheit) of saturated steam increases as pressure increases. This relationship is approximated by the model

$$T = 75.82 - 2.11x + 43.51\sqrt{x}, \quad 5 \le x \le 40$$

where x is the absolute pressure in pounds per square inch.

(a) Use a graphing utility to graph the temperature function over the specified domain.

(b) The temperature of steam at sea level ($x = 14.696$) is 212°F. Evaluate the model at this pressure, and verify the result graphically.

(c) Use the model to approximate the pressure for a steam temperature of 240°F.

115. *Fuel Efficiency* The distance d a car can travel on one tank of fuel is approximated by the model

$$d = -0.024s^2 + 1.455s + 431.5, \quad 0 < s \le 75$$

where s is the average speed of the car.

(a) Use a graphing utility to graph the distance function over the specified domain.

(b) Use the graph to determine the greatest distance that can be traveled on a tank of fuel. How long will the trip take?

(c) Determine the greatest distance that can be traveled in this car in 8 hours with no refueling. How fast should the car be driven? [*Hint:* The distance traveled in 8 hours is $8s$. Graph this expression in the same viewing rectangle as the graph in part (a) and approximate the point of intersection.]

116. *Solving Graphically, Numerically, and Algebraically* A meteorologist is positioned 100 feet from the point where a weather balloon is launched. When the balloon is at height h, the distance d between the meteorologist and the balloon is given by $d = \sqrt{100^2 + h^2}$.

(a) Use a graphing utility to graph the equation. Use the trace feature to approximate the value of h when $d = 200$.

(b) Complete the table. Use the table to approximate the value of h when $d = 200$.

h	160	165	170	175	180	185
d						

(c) Find h algebraically when $d = 200$.

(d) Compare the results of each method. In each case, what information did you gain that wasn't revealed by another solution method?

In Exercises 117 and 118, solve for the variable.

117. *Surface Area of a Cone*
Solve for h: $S = \pi r\sqrt{r^2 + h^2}$

118. *Inductance*
Solve for Q: $i = \pm\sqrt{\frac{1}{LC}}\sqrt{Q^2 - q}$

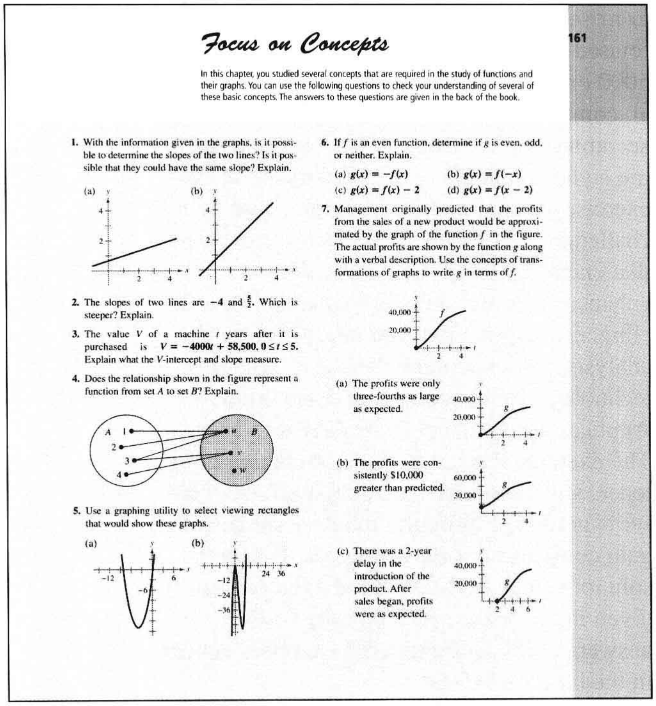
In Exercises 119 and 120, consider an equation of the form $x + \sqrt{x - a} = b$, where a and b are constants.

119. *Exploration* Find a and b if the solution to the equation is $x = 20$. (There are many correct answers.)

120. *Essay* Write a short paragraph listing the steps required for solving an equation involving radicals.

Geometry Geometric formulas and concepts are reviewed throughout the text in examples, Group Activities, and exercises. For reference, common formulas are listed inside the back cover of this text.

Focus on Concepts Each Focus on Concepts feature is a set of exercises that test students' understanding of the basic concepts covered in the chapter. Answers to all questions are given in the back of the text.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Focus on Concepts

In this chapter, you studied several concepts that are required in the study of functions and their graphs. You can use the following questions to check your understanding of several of these basic concepts. The answers to these questions are given in the back of the book.

1. With the information given in the graphs, is it possible to determine the slopes of the two lines? Is it possible that they could have the same slope? Explain.

2. The slopes of two lines are -4 and $\frac{5}{2}$. Which is steeper? Explain.

3. The value V of a machine t years after it is purchased is $V = -4000t + 58{,}500$, $0 \le t \le 5$. Explain what the V-intercept and slope measure.

4. Does the relationship shown in the figure represent a function from set A to set B? Explain.

5. Use a graphing utility to select viewing rectangles that would show these graphs.

6. If f is an even function, determine if g is even, odd, or neither. Explain.

(a) $g(x) = -f(x)$ (b) $g(x) = f(-x)$

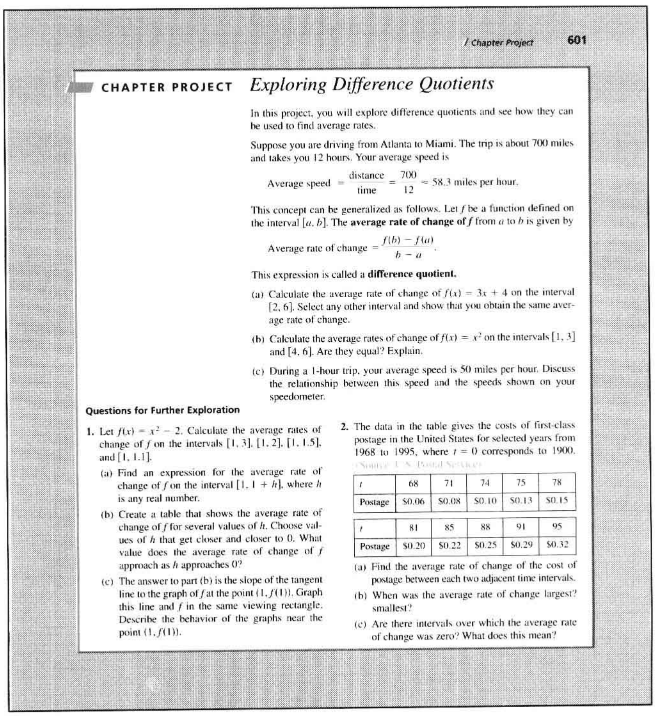
(c) $g(x) = f(x) - 2$ (d) $g(x) = f(x - 2)$

7. Management originally predicted that the profits from the sales of a new product would be approximated by the graph of the function f in the figure. The actual profits are shown by the function g along with a verbal description. Use the concepts of transformations of graphs to write g in terms of f.

(a) The profits were only three-fourths as large as expected.

(b) The profits were consistently $10,000 greater than predicted.

(c) There was a 2-year delay in the introduction of the product. After sales began, profits were as expected.


/ Chapter Project 601

CHAPTER PROJECT *Exploring Difference Quotients*

In this project, you will explore difference quotients and see how they can be used to find average rates.

Suppose you are driving from Atlanta to Miami. The trip is about 700 miles and takes you 12 hours. Your average speed is

$$\text{Average speed} = \frac{\text{distance}}{\text{time}} = \frac{700}{12} \approx 58.3 \text{ miles per hour.}$$

This concept can be generalized as follows. Let f be a function defined on the interval $[a, b]$. The **average rate of change of f** from a to b is given by

$$\text{Average rate of change} = \frac{f(b) - f(a)}{b - a}.$$

This expression is called a **difference quotient.**

(a) Calculate the average rate of change of $f(x) = 3x + 4$ on the interval $[2, 6]$. Select any other interval and show that you obtain the same average rate of change.

(b) Calculate the average rates of change of $f(x) = x^2$ on the intervals $[1, 3]$ and $[4, 6]$. Are they equal? Explain.

(c) During a 1-hour trip, your average speed is 50 miles per hour. Discuss the relationship between this speed and the speeds shown on your speedometer.

Questions for Further Exploration

1. Let $f(x) = x^2 - 2$. Calculate the average rates of change of f on the intervals $[1, 3]$, $[1, 2]$, $[1, 1.5]$, and $[1, 1.1]$.

(a) Find an expression for the average rate of change of f on the interval $[1, 1 + h]$, where h is any real number.

(b) Create a table that shows the average rate of change of f for several values of h. Choose values of h that get closer and closer to 0. What value does the average rate of change of f approach as h approaches 0?

(c) The answer to part (b) is the slope of the tangent line to the graph of f at the point $(1, f(1))$. Graph this line and f in the same viewing rectangle. Describe the behavior of the graphs near the point $(1, f(1))$.

2. The data in the table gives the costs of first-class postage in the United States for selected years from 1968 to 1995, where $t = 0$ corresponds to 1900. (Source: U.S. Postal Service)

t	68	71	74	75	78
Postage	$0.06	$0.08	$0.10	$0.13	$0.15

t	81	85	88	91	95
Postage	$0.20	$0.22	$0.25	$0.29	$0.32

(a) Find the average rate of change of the cost of postage between each two adjacent time intervals.

(b) When was the average rate of change largest? smallest?

(c) Are there intervals over which the average rate of change was zero? What does this mean?

Chapter Projects Chapter Projects are extended applications that use real data, graphs, and modeling to enhance students' understanding of mathematical concepts. Designed as individual or group projects, they offer additional opportunities to think, discuss, and write about mathematics. Many projects give students the opportunity to collect, analyze, and interpret data.

Review Exercises The Review Exercises at the end of each chapter offer students an opportunity for additional practice. Answers to odd-numbered review exercises are given in the back of the text.

162 1 / *Functions and Their Graphs*

1 /// REVIEW EXERCISES

In Exercises 1 and 2, complete the table. Use the resulting solution points to sketch the graph of the equation. Use a graphing utility to verify the graph.

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

x	-2	0	2	3	4
y					

2. $y = x^2 - 3x$

x	-1	0	1	2	3
y					

In Exercises 3–12, sketch the graph of the equation *by hand*. Use a graphing utility to verify the graph.

3. $y - 2x - 3 = 0$ **4.** $3x + 2y + 6 = 0$
5. $x - 5 = 0$ **6.** $y = 8 - |x|$
7. $y = \sqrt{5 - x}$ **8.** $y = \sqrt{x + 2}$
9. $y + 2x^2 = 0$ **10.** $y = x^2 - 4x$
11. $y = \sqrt{25 - x^2}$ **12.** $x^2 + y^2 = 10$

In Exercises 13–20, use a graphing utility to graph the equation. Approximate any intercepts.

13. $y = \frac{1}{4}(x + 1)^3$ **14.** $y = 4 - (x - 4)^2$
15. $y = \frac{1}{4}x^4 - 2x^2$ **16.** $y = \frac{1}{4}x^3 - 3x$
17. $y = x\sqrt{9 - x^2}$ **18.** $y = x\sqrt{x + 3}$
19. $y = |x - 4| - 4$ **20.** $y = |x + 2| + |3 - x|$

In Exercises 21 and 22, find a setting on a graphing utility such that the graph of the equation agrees with the given graph.

21. $y = 0.002x^2 - 0.06x - 1$
22. $y = 10x^3 - 21x^2$

Figure for 21

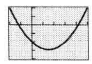
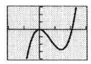


Figure for 22



Data Analysis In Exercises 23 and 24, (a) use a graphing utility to plot the data; (b) use a graphing utility's least squares regression capabilities to find the best-fitting linear model (let $t = 0$ correspond to 1990); (c) graph the model in the same viewing rectangle with the data, and sketch the model for the data; and (d) use the model to estimate the values of y for the years 1998 and 2000.

23. The total annual expenditures y for the Smithsonian Institution (in millions) each year from 1990 through 1993 are given in the table. (Source: U.S. Department of Treasury)

x	1990	1991	1992	1993
y	302	340	387	395

24. The total annual expenditures y for NASA (in billions) from 1990 through 1993 are given in the table. (Source: U.S. Department of Treasury)

x	1990	1991	1992	1993
y	12.4	13.9	14.0	14.3

Chapter Tests Each chapter that is not followed by a Cumulative Test ends with a Chapter Test, an effective tool for student self-assessment.

314 3 / *Polynomial and Rational Functions*

3 /// CHAPTER TEST

Take this test as you would take a test in class. After you are done, check your work against the answers given in the back of the book.

The *Interactive* CD-ROM provides answers to the Chapter Tests and Cumulative Tests. It also offers Chapter Pre-Tests (that test key skills and concepts covered in previous chapters) and Chapter Post-Tests, both of which have randomly generated exercises with diagnostic capabilities.

1. Describe how the graph of g differs from the graph of $f(x) = x^2$.
(a) $g(x) = 2 - x^2$ (b) $g(x) = (x - \frac{3}{2})^2$

2. Identify the vertex and intercepts of the graph of $y = x^2 + 4x + 3$.

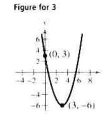
3. Find an equation of the parabola shown at the right.

4. The path of a ball is given by $y = -\frac{1}{20}x^2 + 3x + 5$, where y is the height in feet and x is the horizontal distance in feet.
(a) Find the maximum height of the ball.
(b) Which term determines the height at which the ball was thrown? Does changing this term change the coordinates of the maximum height of the ball? Explain.

5. Divide by long division: $(3x^3 + 4x - 1) \div (x^2 + 1)$.

6. Divide by synthetic division: $(2x^4 - 5x^2 - 3) \div (x - 2)$.

Figure for 3



In Exercises 7 and 8, list all the possible rational zeros of the function. Use a graphing utility to graph the function and find all the rational zeros.

7. $g(t) = 2t^4 - 3t^3 + 16t - 24$ **8.** $h(x) = 3x^5 + 2x^4 - 3x - 2$

In Exercises 9 and 10, use the root-finding capabilities of a graphing utility to approximate the real zeros of the function accurate to three decimal places.

9. $f(x) = x^4 - x^3 - 1$ **10.** $f(x) = 3x^5 + 2x^4 - 12x - 8$

In Exercises 11 and 12, find a polynomial function with integer coefficients that has the given zeros.

11. $0, 3, 3 + i, 3 - i$ **12.** $1 + \sqrt{3}i, 1 - \sqrt{3}i, 2, 2$

In Exercises 13 and 14, use a graphing utility to graph the function.

13. $h(x) = \dfrac{4}{x^2} - 1$ **14.** $g(x) = \dfrac{x^2 + 2}{x - 1}$

15. Find a rational function with vertical asymptotes at $x = \pm 3$ and a horizontal asymptote at $y = 4$.

Cumulative Tests The Cumulative Tests that follow Chapters 2, 5, and 8 help students judge their mastery of previously covered material as well as reinforce the knowledge they have been accumulating throughout the text—preparing them for other exams and for future courses.

456 / *Cumulative Test for Chapters 3–5*

3–5 /// CUMULATIVE TEST

Take this test as you would take a test in class. After you are done, check your work against the answers given in the back of the book.

The *Interactive* CD-ROM provides answers to the Chapter Tests and Cumulative Tests. It also offers Chapter Pre-Tests (that test key skills and concepts covered in previous chapters) and Chapter Post-Tests, both of which have randomly generated exercises with diagnostic capabilities.

In Exercises 1–6, use a graphing utility to graph the function.

1. $h(x) = -(x^2 + 4x)$ **2.** $f(t) = \frac{1}{4}t(t - 2)^2$ **3.** $g(s) = \dfrac{2s}{s - 3}$

4. $g(s) = \dfrac{2s^2}{s - 3}$ **5.** $f(x) = 6(2^{-x})$ **6.** $g(x) = \log_3 x$

7. Let x be the amount (in hundreds of dollars) that a company spends on advertising, and let P be the profit (in thousands of dollars), where $P = 230 + 20x - \frac{1}{2}x^2$. How much advertising will maximize the profit?

8. Find all the zeros of $f(x) = x^3 + 2x^2 + 4x + 8$.

9. Approximate the real zero of $g(x) = x^3 + 3x^2 - 6$ to the nearest hundredth.

10. Write $2 \ln x - \frac{1}{2} \ln(x + 5)$ as a logarithm of a single quantity.

11. You deposit $2500 in an account earning 7.5% interest, compounded continuously. Find the balance after 25 years.

In Exercises 12 and 13, solve the equation algebraically. Verify graphically.

12. $6e^{2x} = 72$ **13.** $\log_2 x + \log_2 5 = 6$

In Exercises 14 and 15, solve the system by the specified method.

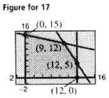
14. Substitution: $2x - y^2 = 0$, $x - y = 4$ **15.** Graphical: $y = \log_3 x$, $y = -\frac{1}{3}x + 2$

16. Find the equation of the parabola $y = ax^2 + bx + c$ passing through the points $(0, 6)$, $(-2, 2)$, and $(3, \frac{9}{2})$.

17. Derive a set of inequalities to describe the region shown in the figure.

18. A merchant plans to sell two models of compact disc players. One model sells for $275 and yields a profit of $55, and the other model sells for $400 and yields a profit of $75. The merchant estimates that the total monthly demand will not exceed 300 units. The merchant does not want to invest more than $100,000 in inventory for these products. Find the number of units of each model that should be stocked in order to maximize profit.

Figure for 17



Supplements

College Algebra: A Graphing Approach, Second Edition, by Larson, Hostetler, and Edwards is accompanied by a comprehensive supplements package. Most items are keyed to the text.

Printed Resources

For the student

Study and Solutions Guide by Bruce Edwards, University of Florida, and Dianna L. Zook, Indiana University—Purdue University at Fort Wayne

- Section summaries of key concepts
- Detailed, step-by-step solutions to all odd-numbered exercises
- Key solution steps for Chapter Tests and Cumulative Tests
- Practice tests with solutions
- Study strategies

Graphing Technology Keystroke Guide: Precalculus

- Keystroke instructions for a wide variety of Texas Instruments, Casio, Sharp, and Hewlett-Packard graphing calculators—including the most current models.
- Examples with step-by-step solutions
- Extensive graphics screen output
- Technology tips

For the instructor

Instructor's Annotated Edition

- Includes the entire student edition of the text, with the student answers section
- Instructor's Answers section: Answers to all even-numbered exercises, and answers to all Explorations, Technology exercises, Group Activities, and Chapter Project exercises
- Annotations at point of use offer specific teaching strategies and suggestions for implementing Group Activities, point out common student errors, and give additional examples, exercises, class activities, and group activities.

Solutions to Even-Numbered Exercises

- Detailed, step-by-step solutions to even-numbered exercises

Test Item File and Instructor's Resource Guide

- Printed test bank with approximately 2000 test items (multiple-choice, open-ended, and writing) coded by level of difficulty
- Technology-required test items coded for easy reference
- Bank of chapter test forms with answer keys

- Two final exam test forms
- Notes to the instructor, including materials for alternative assessment and managing the multicultural and cooperative-learning classrooms

Problem Solving, Modeling, and Data Analysis Labs by Wendy Metzger, Palomar College

- Multipart, guided discovery activities and applications
- Keystroke instructions for Derive and *TI-82*
- Keyed to the text by topic
- Funded in part by NSF (National Science Foundation, Instrumentation and Laboratory Improvement) and California Community College Fund for Instructional Improvement

Media Resources

For the student

Interactive College Algebra: A Graphing Approach (See pages xviii–xx for a description, or visit the Houghton Mifflin home page at http://www.hmco.com for a preview.)

- Interactive, multimedia CD-ROM format
- IBM-PC for Windows

Tutor software

- Interactive tutorial software keyed to the text by section
- Diagnostic feedback
- Chapter self-tests
- Guided exercises with step-by-step solutions
- Glossary

Videotapes by Dana Mosely

- Comprehensive, text-specific coverage keyed to the text by section
- Real-life application vignettes introduced where appropriate
- Computer-generated animation
- For media/resource centers
- Additional explanation of concepts, sample problems, and applications
- Instructional graphing calculator videotape also available

For the instructor

Computerized Testing (IBM, Macintosh, Windows)

- New on-line testing
- New grade-management capabilities
- Algorithmic test-generating software provides an unlimited number of tests
- Approximately 2000 test items
- Also available as a printed test bank

Transparency Package

- 50 color transparencies color-coded by topic