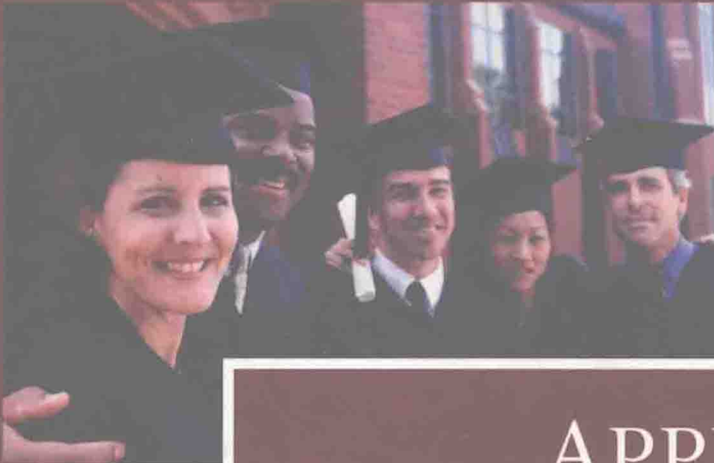
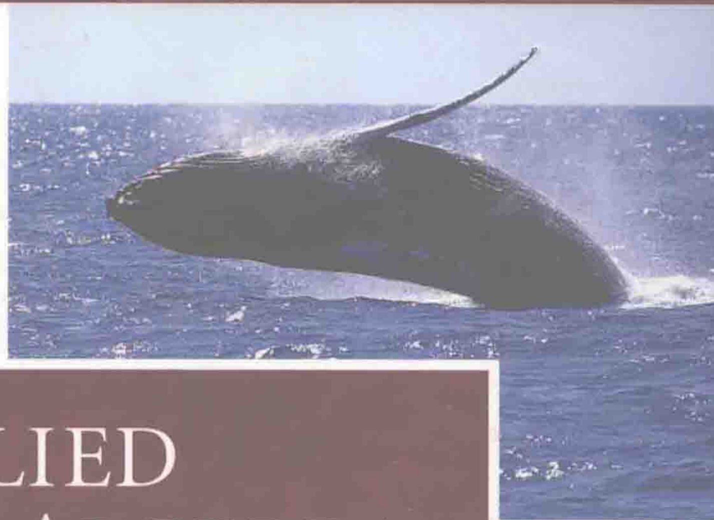
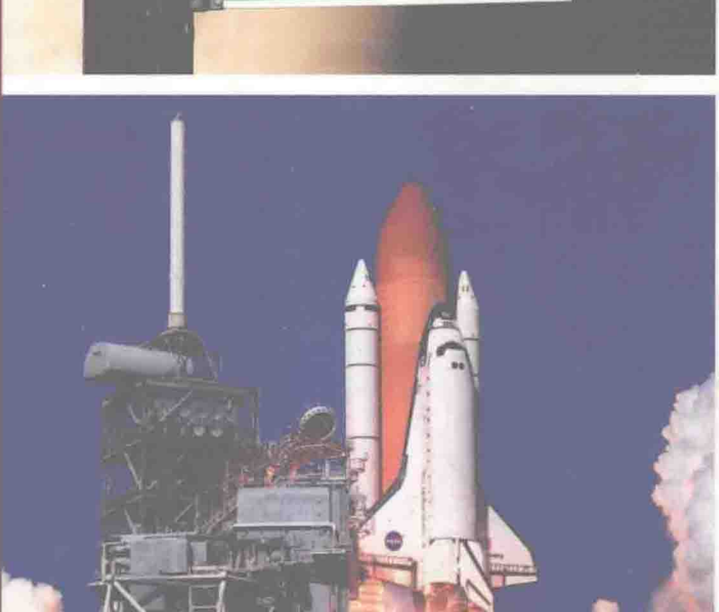
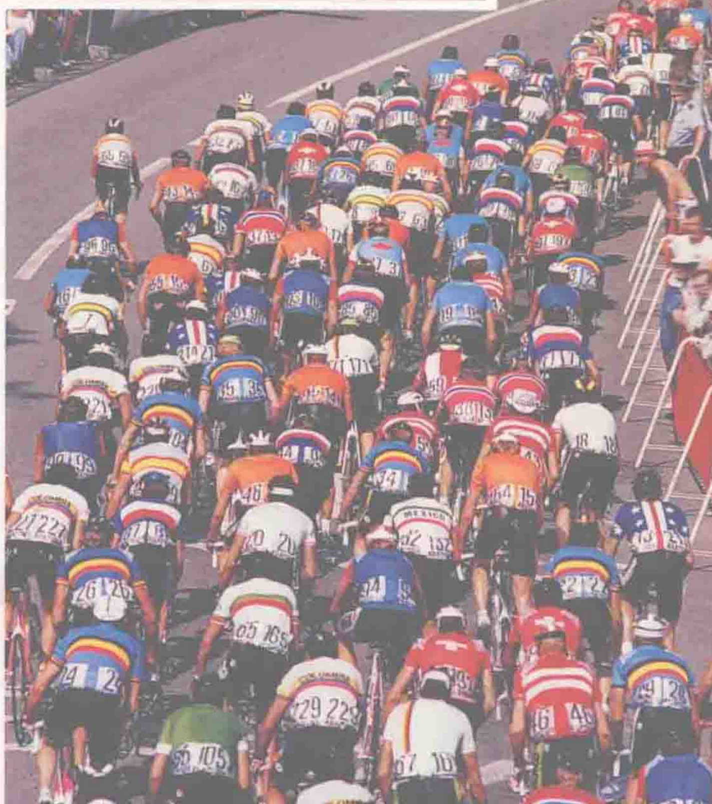




APPLIED COLLEGE ALGEBRA





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Preface

Applied College Algebra is a new text designed to assist students in making connections between mathematics and its applications. Our goal is to develop a student's mathematical skills through appropriate use of applications and to establish links between abstract mathematical concepts and visual representations or concrete applications.

Our hallmark *interactive approach,* which encourages students to practice a skill or concept as it is presented and get immediate feedback, is also highlighted in this text. For each numbered Example within a section, there is a similar *Check Your Progress* problem for the student to try. The numbered example is worked out; the *Check Your Progress* is for the student to work. By solving this problem, the student actively practices concepts as they are presented in the text. There are *complete worked-out* solutions to the *Check Your Progress* problems in an appendix. Students can compare their solution to the solution in the appendix and thereby obtain immediate feedback on the concept. In addition, by providing complete worked-out solutions to the *Check Your Progress,* it significantly increases the number of examples available for students to refer to when doing homework or studying for a test.

The application of algebra is a central theme of this text. We have not only provided applications from traditional disciplines such as the physical sciences and engineering but have incorporated, among others, applications from business, economics, social science, life science, health science, and sports. The application topics provide instructors with numerous options for engaging students with diverse interests and allow instructors to customize the course to address the needs of students with a variety of career goals.

Through the use of applications, we demonstrate to students that mathematics has a vast array of tools that can be used to solve relevant, meaningful problems. Modeling, analytic representation, and verbal representations of problems and their solutions are encouraged. We have also integrated numerous data analysis exercises throughout the text and encourage students to derive meaningful conclusions about the data.

In some cases, we have incorporated a writing component to an exercise that asks the student to write a few sentences explaining the meaning of an answer in the context of the problem. Additional writing exercises are integrated throughout most exercise sets. These exercises ask students to make a conjecture based on some given facts, restate a concept in their own words, provide a written answer to a question, or research a topic and write a short report.

We have paid special attention to the standards suggested by AMATYC and have made a serious attempt to incorporate these standards in the text. Problem solving, critical analysis, function concept, connecting mathematics to other disciplines through applications, multiple representations of concepts, and the appropriate use of technology are all integrated within this text. Our goal is to provide students with a variety of analytical tools that will make them more effective quantitative thinkers and problem solvers.

Chapter Opening Features

Chapter Opener

Each chapter begins with a **Chapter Opener** that illustrates a specific application of a concept from the chapter. This application references an exercise in the chapter where students solve a problem related to the chapter opener topic.

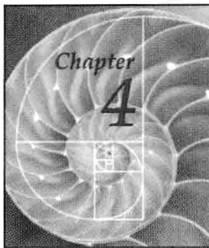
57. *Wedding Expenses* The function $C(t) = 17t^2 + 128t + 5900$ models the average cost of a wedding reception and the function $W(t) = 38t^2 + 291t + 15{,}208$ models the average cost of a wedding, where $t = 0$ represents the year 1990 and $0 \le t \le 12$. The rational function

$$R(t) = \frac{C(t)}{W(t)} = \frac{17t^2 + 128t + 5900}{38t^2 + 291t + 15{,}208}$$

gives the relative cost of the reception compared to the cost of a wedding.

a. Use $R(t)$ to estimate the relative cost of the reception compared to the cost of a wedding for the years $t = 0$, $t = 7$, and $t = 12$. Round your results to the nearest tenth of a percent.

page 373



Chapter 4

Polynomial and Rational Functions

Section 4.1	The Remainder Theorem and the Factor Theorem
Section 4.2	Polynomial Functions of Higher Degree
Section 4.3	Zeros of Polynomial Functions
Section 4.4	The Fundamental Theorem of Algebra
Section 4.5	Graphs of Rational Functions and Their Applications

Wedding Expenses

In this chapter you will study polynomial and rational functions. These types of functions have many practical applications. They can be used to model and analyze wedding expenses, as shown below.

The average cost of a wedding was \$15,208 in 1990, \$19,104 in 1997, and about \$23,000 in 2001. The table to the right lists some of the average costs associated with a wedding in 1990 and in 1997.

The polynomial function $D(t) = 4.8t + 793$ models the average cost of a wedding dress, and the function $W(t) = 38t^2 + 291t + 15{,}208$ models the average cost of a wedding, where $t = 0$ represents the year 1990 and $0 \le t \le 12$. The rational function

$$R(t) = \frac{4.8t + 793}{38t^2 + 291t + 15{,}208}$$

represents the relative cost of a wedding dress compared to the cost of a wedding. For $t = 0$, $t = 7$, and $t = 12$, we find that $R(0) \approx 5.2\%$, $R(7) \approx 4.3\%$, and $R(12) \approx 3.5\%$.

Thus, although the average price of a wedding dress has steadily increased over the last few years, the relative cost of a wedding dress, compared to the average cost of a wedding, has decreased.

Another wedding expense application is given in Exercise 57, page 373.

Category	Average cost, 1990	Average cost, 1997
Flowers	\$478	\$756
Music	\$882	\$830
Rehearsal dinner	\$501	\$698
Wedding dress	\$794	\$823
Reception	\$5900	\$7635

Source: Bride's Magazine, 1997 Millennium Report (**EmeraldWeddings.com**)

page 311

Chapter Prep Quiz

Do these exercises to prepare for Chapter 1.

1. Simplify: $\sqrt{12}$ [P.6]*
2. Simplify: $3(2x - 1) - 4(3x - 2)$ [P.3]
3. Factor: $x^2 - 16x + 64$ [P.4]
4. Factor: $x^4 + 2x^2 - 3$ [P.4]
5. Express "the distance between a real number x and 5 is less than 3" using absolute value notation. [P.1]
6. Simplify: $\frac{-4 + \sqrt{-16}}{2}$ [P.7]
7. Write $\frac{x}{x + 1} - 2$ as a rational expression. [P.5]
8. Evaluate $\frac{-b + \sqrt{b^2 - 4ac}}{2a}$ with $a = 2$, $b = -4$, and $c = 1$. [P.6]
9. Find $\{x \mid x \ge -1\} \cup \{x \mid x < 5\}$. [P.1]
10. Find $\{x \mid x \ge 3\} \cap \{x \mid x > 1\}$. [P.1]

Problem Solving Strategies

Verifying Results

One important aspect of problem solving involves the process of checking to see if your results satisfy the conditions of the original problem. This process will be especially important in this chapter when you solve an equation or an inequality.

Here is an example that illustrates the importance of checking your results. The problem seems easy, but many students fail to get the correct answer on their first attempt.

Two volumes of the series *Mathematics: Its Content, Methods, and Meaning* are on a shelf, with no space between the volumes. Each volume is 1 inch thick without its covers. Each cover is $\frac{1}{8}$ inch thick. A bookworm bores horizontally from the first page of Volume I to the last page of Volume II. How far does the bookworm travel?

Once you have obtained your solution, try to check it by closely examining two books placed as shown above. Check to make sure you have the proper starting and ending positions. The correct answer is $\frac{1}{4}$ inch.

*This is a reference to the section that corresponds to this problem. For example, [P.6] stands for Chapter P, Section 6.

page 82

Prep Quiz and Problem Solving Strategies

Chapter Prep Quizzes occur at the beginning of each chapter and test students on previously covered concepts that are required in order to succeed in the upcoming chapter. Next to each question, in brackets, is a reference to the section of the text that contains the concepts related to the question to allow students to refer back for help. All answers are provided in Answers to Selected Exercises.

Problem Solving Strategies give students insight into successful problem-solving strategies and help students better understand how they are used.

Aufmann Interactive Method (AIM)

This text is written in a style that encourages the student to interact with the textbook.

An Interactive Approach

Applied College Algebra uses an interactive approach that provides students with an opportunity to try a skill as it is presented. This feature can be used by instructors as an easy way to immediately check for student understanding and to actively engage students in practicing concepts as they are presented.

For each numbered Example within a section, there is a similar *Check Your Progress* problem for the student to work. Each *Check Your Progress* problem references a page in the back of the text where the full solution is presented—rather than just the answer. By including the full solution, the *Check Your Progress* exercises provide students immediate feedback on their understanding of the concepts and serve as additional examples for students to refer to while studying.

Question/Answer

At various places during a discussion, we ask students to respond to a **Question** about the material being presented. This question encourages students to pause and think about the mathematics. To make sure students do not miss important information, and to help those students studying independently, the **Answer** to the question is provided as a footnote at the bottom of the page.

414 CHAPTER 5 Exponential and Logarithmic Functions

TAKE NOTE

Pay close attention to these properties. Note that

$$\log_b(MN) \neq \log_b M \cdot \log_b N$$

and

$$\log_b \frac{M}{N} \neq \frac{\log_b M}{\log_b N}$$

Also,

$$\log_b(M + N) \neq \log_b M + \log_b N$$

In fact, the expression $\log_b(M + N)$ cannot be expanded at all.

Properties of Logarithms

In the following properties, b, M, and N are positive real numbers ($b \neq 1$).

Product property	$\log_b(MN) = \log_b M + \log_b N$
Quotient property	$\log_b \frac{M}{N} = \log_b M - \log_b N$
Power property	$\log_b(M^p) = p \log_b M$
Logarithm-of-each-side property	$M = N$ implies $\log_b M = \log_b N$
One-to-one property	$\log_b M = \log_b N$ implies $M = N$

QUESTION Is it true that $\ln 5 + \ln 10 = \ln 50$?

The above properties of logarithms are often used to rewrite logarithmic expressions in an equivalent form.

EXAMPLE 1 Rewrite Logarithmic Expressions

Use the properties of logarithms to express the following logarithms in terms of logarithms of x, y, and z.

a. $\log_5(xy^2)$ **b.** $\log_b \frac{2\sqrt{y}}{z^5}$

Solution

a. $\log_5(xy^2) = \log_5 x + \log_5 y^2$ • Product property

$= \log_5 x + 2\log_5 y$ • Power property

b. $\log_b \frac{2\sqrt{y}}{z^5} = \log_b(2\sqrt{y}) - \log_b z^5$ • Quotient property

$= \log_b 2 + \log_b \sqrt{y} - \log_b z^5$ • Product property

$= \log_b 2 + \log_b y^{1/2} - \log_b z^5$ • Replace $\sqrt{y}$ with $y^{1/2}$

$= \log_b 2 + \frac{1}{2}\log_b y - 5\log_b z$ • Power property

CHECK YOUR PROGRESS 1 Use the properties of logarithms to express $\ln \frac{z^3}{\sqrt{xy}}$ in terms of logarithms of x, y, and z.

Solution *See page S25.*

The properties of logarithms are also used to rewrite expressions that involve several logarithms as a single logarithm.

ANSWER Yes. By the product property, $\ln 5 + \ln 10 = \ln(5 \cdot 10)$.

page 414

Section 5.3

Check Your Progress 1, *page 414*

$$\ln \frac{z^3}{\sqrt{xy}} = \ln z^3 - \ln\sqrt{xy}$$
$$= \ln z^3 - \ln(xy)^{1/2}$$
$$= 3\ln z - \frac{1}{2}\ln(xy)$$
$$= 3\ln z - \frac{1}{2}(\ln x + \ln y)$$
$$= 3\ln z - \frac{1}{2}\ln x - \frac{1}{2}\ln y$$

page S25

AIM for Success Student Preface

This "how to use this book" student preface explains what is required of a student to be successful in mathematics and how this text has been designed to foster student success through the Aufmann Interactive Method (AIM). *AIM for Success* can be used as a lesson on the first day of class or as a project for students to complete to strengthen their study skills. There are suggestions for teaching this lesson in the *Instructor's Resource Manual* and on the *Class Prep CD*.

AIM for Success

Welcome to *Applied College Algebra*. As you begin this course, we know two important facts: (1) We want you to succeed. (2) You want to succeed. To do that requires an effort from each of us. For the next few pages, we are going to show you what is required of you to achieve that success and how you can use the features of this text to be successful.

Motivation One of the most important keys to success is motivation. We can try to motivate you by offering interesting or important ways mathematics can benefit you. But, in the end, the motivation must come from you. On the first day of class, it is easy to be motivated. Eight weeks into the term, it is harder to keep that motivation.

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Real Data and Applications

Applications

One way to motivate an interest in mathematics is through applications. This carefully integrated, applied approach generates student awareness of the value of algebra as a relevant real-life tool.

Applications in this text are taken from many disciplines to address the diverse interests and backgrounds of students. Topics include agriculture, business, carpentry, chemistry, construction, Earth science, health science, education, manufacturing, nutrition, real estate, sports, and sociology.

Wherever appropriate, applications use problem-solving strategies to solve practical problems.

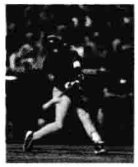
146 CHAPTER 1 Equations and Inequalities

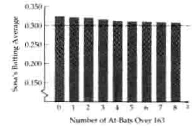
▪ Applications of Quadratic and Rational Inequalities

Quadratic inequalities and rational inequalities are often used to solve applied problems. Here are a few examples.

EXAMPLE 5 Solve an Application Involving Batting Averages

Near the end of May 2002, Sammy Sosa had 53 hits out of 163 at-bats. At that time his batting average was approximately 0.325. If Sosa goes into a batting slump in which he gets no hits, how many more at-bats will it take for his batting average to fall below 0.300?





Solution A baseball player's batting average is determined by dividing the player's number of hits by the number of times the player has been at bat. Let x be the number of additional at-bats that Sosa takes over 163. During this period his batting average will be $\frac{53}{163 + x}$, and we wish to solve

$$\frac{53}{163 + x} < 0.300$$

This rational inequality can be solved by using a sign diagram or the critical value method, but there is an easier method. In this application we know that $163 + x$ is positive. Thus if we multiply each side of the above inequality by $163 + x$, we will obtain the linear inequality $53 < 48.9 + 0.300x$, with the condition that x is a positive integer. Solving this inequality produces

$$53 < 48.9 + 0.300x$$
$$4.1 < 0.300x$$
$$x > 13.\overline{6}$$

Because x must be a positive integer, Sosa's average will fall below 0.300 if he goes hitless for 14 or more at-bats.

CHECK YOUR PROGRESS 5 Assume Sammy Sosa has 53 hits out of 163 at-bats. If Sosa goes into a hitting streak in which he gets a hit every time he bats, how many more at-bats will it take for his batting average to exceed 0.350?

Solution *See page S9.*

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462 CHAPTER 5 Exponential and Logarithmic Functions

Life and Health Sciences

16. *Generation of Garbage* According to the U.S. Environmental Protection Agency, the amount of garbage generated per person has been increasing over the last few decades. The following table shows the per capita garbage, in pounds per day, generated in the United States.

Year, t	1960	1970	1980	1990	2000
Pounds per day, p	2.66	3.27	3.61	4.00	4.30

Represent the year 1960 by $t = 60$.

a. Use a graphing utility to find a linear model and a logarithmic model for the data. Use t as the independent variable (domain) and p as the dependent variable (range).

b. Examine the correlation coefficients of the two regression models to determine which model provides a better fit for the data.

c. Use the model you selected in part **b.** to predict the amount of garbage that will be generated per capita per day in 2005. Round to the nearest hundredth of a pound.

17. *The Henderson-Hasselbach Function* The scientists Henderson and Hasselbach determined that the pH of blood is a function of the ratio q of the amounts of bicarbonate and carbonic acid in the blood.

a. Use a graphing utility and the data in the following table to determine a linear model and a logarithmic model for the data. Use q as the independent variable (domain) and pH as the dependent variable (range). State the correlation coefficient for each model. Round a and b to 5 decimal places and r to 6 decimal places. Which model provides the better fit for the data?

q	7.9	12.6	31.6	50.1	79.4
pH	7.0	7.2	7.6	7.8	8.0

b. Use the model you chose in part **a.** to find the q-value associated with a pH of 8.2. Round to the nearest tenth.

18. *World Population* The following table lists the years in which the world's population first reached 3, 4, 5, and 6 billion.

World Population Milestones

1960	3 billion
1974	4 billion
1987	5 billion
1999	6 billion

Source: Time Almanac 2002, page 708.

a. Find an exponential model for the data in the table. Let $x = 0$ represent the year 1960.

b. Use the model to predict the year in which the world's population will first reach 7 billion.

19. *Panda Population* One estimate gives the world panda population as 3200 in 1980 and 590 in 2000.

a. Find an exponential model for the data and use the model to predict the year in which the panda population p will be reduced to 200. (Let $t = 0$ represent the year 1980.)

b. Because the exponential model in part **a.** fits the data perfectly, does this mean that the model will accurately predict future panda populations? Explain.

Sports and Recreation

20. *Olympic Records* The following table shows the Olympic gold medal distances for the women's high jump from 1968 to 2000.

Women's Olympic High Jump, 1968 to 2000

Year	Distance	Year	Distance
1968	5 ft $11\frac{3}{4}$ in.	1984	6 ft $7\frac{1}{2}$ in.
1972	6 ft $3\frac{5}{8}$ in.	1988	6 ft 8 in.
1976	6 ft 4 in.	1992	6 ft $7\frac{1}{2}$ in.
1980	6 ft $5\frac{1}{2}$ in.	1996	6 ft $8\frac{3}{4}$ in.
		2000	6 ft 7 in.

Source: Time Almanac 2002

Represent the year 1968 by 68.

page 462

Real Data

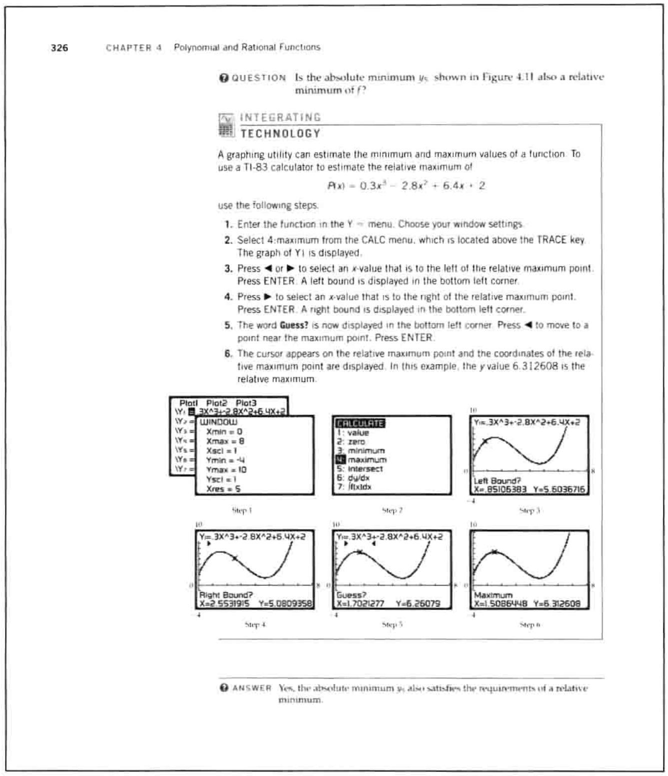
Real data examples and exercises, identified by [icon], ask students to analyze and solve problems taken from actual situations. Students often work with tables, graphs, and charts drawn from a variety of disciplines.

Technology

Integrating Technology

The Integrating Technology feature contains discussions that can be used to further explore a concept using technology. Some introduce technology as an alternative way to solve certain problems and others provide suggestions for using a calculator to solve certain problems and applications.

Additionally, optional graphing calculator examples and exercises (identified by) are presented throughout the text.



326 CHAPTER 4 Polynomial and Rational Functions

QUESTION Is the absolute minimum y_5 shown in Figure 4.11 also a relative minimum of f?

INTEGRATING TECHNOLOGY

A graphing utility can estimate the minimum and maximum values of a function. To use a TI-83 calculator to estimate the relative maximum of

$$P(x) = 0.3x^3 - 2.8x^2 + 6.4x + 2$$

use the following steps.

1. Enter the function in the Y = menu. Choose your window settings.
2. Select 4:maximum from the CALC menu, which is located above the TRACE key. The graph of Y1 is displayed.
3. Press ◄ or ► to select an x-value that is to the left of the relative maximum point. Press ENTER. A left bound is displayed in the bottom left corner.
4. Press ► to select an x-value that is to the right of the relative maximum point. Press ENTER. A right bound is displayed in the bottom left corner.
5. The word **Guess?** is now displayed in the bottom left corner. Press ◄ to move to a point near the maximum point. Press ENTER.
6. The cursor appears on the relative maximum point and the coordinates of the relative maximum point are displayed. In this example, the y value 6.312608 is the relative maximum.

ANSWER Yes, the absolute minimum y_5 also satisfies the requirements of a relative minimum.

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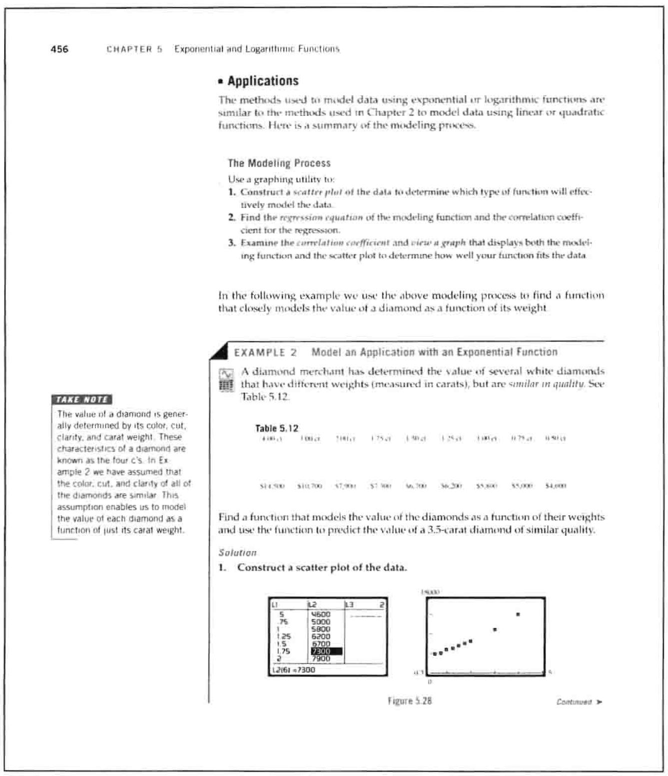

456 CHAPTER 5 Exponential and Logarithmic Functions

▪ Applications

The methods used to model data using exponential or logarithmic functions are similar to the methods used in Chapter 2 to model data using linear or quadratic functions. Here is a summary of the modeling process.

The Modeling Process

Use a graphing utility to:

1. Construct a *scatter plot* of the data to determine which type of function will effectively model the data.
2. Find the *regression equation* of the modeling function and the correlation coefficient for the regression.
3. Examine the *correlation coefficient* and *view a graph* that displays both the modeling function and the scatter plot to determine how well your function fits the data.

In the following example we use the above modeling process to find a function that closely models the value of a diamond as a function of its weight.

TAKE NOTE

The value of a diamond is generally determined by its color, cut, clarity, and carat weight. These characteristics of a diamond are known as the four c's. In Example 2 we have assumed that the color, cut, and clarity of all of the diamonds are similar. This assumption enables us to model the value of each diamond as a function of just its carat weight.

EXAMPLE 2 Model an Application with an Exponential Function

A diamond merchant has determined the value of several white diamonds that have different weights (measured in carats), but are *similar in quality*. See Table 5.12.

Table 5.12

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Find a function that models the value of the diamonds as a function of their weights and use the function to predict the value of a 3.5-carat diamond of similar quality.

Solution

1. **Construct a scatter plot of the data.**

Figure 5.28

Continued ►

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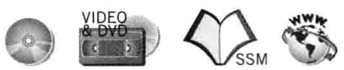
Modeling

Special modeling sections, which rely heavily on the use of a graphing calculator, are incorporated within the text. These optional sections introduce the idea of a mathematical model using various real-world data sets, which further motivate students and help them see the relevance of mathematics.

Student Pedagogy

This text was designed to be an understandable resource for students. Special emphasis was given to readability and effective pedagogical use of color to highlight important words and concepts.

Icons

The 

icons at each objective head remind students of the many and varied additional resources available for each objective.

Key Terms and Important Concepts

A blue bold font is used whenever a **key term** is first introduced.

Important Concepts are presented in yellow boxes in order to highlight these concepts and serve as an easy-to-find reference.

Point of Interest

These margin notes contain interesting comments about mathematics, its history, or its application.

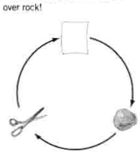
128 CHAPTER 1 Equations and Inequalities

SECTION 1.4 Linear and Absolute Value Inequalities and Their Applications

- **Solve Linear Inequalities**
- **Solve Compound Inequalities**
- **Solve Absolute Value Inequalities**
- **Applications of Inequalities**

Point of Interest

Another property of inequalities, called the *transitive property*, states that for real numbers a, b, and c, if $a > b$ and $b > c$, then $a > c$. Note that a transitive property does not apply in the game of Scissors, Paper, Rock. Scissors wins over paper, paper wins over rock, but scissors does not win over rock!



▪ Solve Linear Inequalities

In Section P.1, we used inequalities to describe the order of real numbers and to represent subsets of real numbers. In this section we consider inequalities that involve a variable. In particular, we consider how to determine which real numbers make an inequality a true statement.

The solution set of an inequality is the set of all real numbers for which the inequality is a true statement. For instance, the solution set of $x + 1 > 4$ is the set of all real numbers greater than 3. Two inequalities are equivalent inequalities if they have the same solution set. We can solve many inequalities by producing *simpler* but equivalent inequalities until the solutions are readily apparent. To produce these simpler but equivalent inequalities, we often apply the following properties.

Properties of Inequalities

Let a, b, and c be real numbers.

1. *Addition-Subtraction Property* If the same real number is added to or subtracted from each side of an inequality, the resulting inequality is equivalent to the original inequality.

   $a < b$ and $a + c < b + c$ are equivalent inequalities.

2. *Multiplication-Division Property*
   a. Multiplying or dividing each side of an inequality by the same *positive* real number produces an equivalent inequality.

      If $c > 0$, then $a < b$ and $ac < bc$ are equivalent inequalities.

   b. Multiplying or dividing each side of an inequality by the same *negative* real number produces an equivalent inequality provided the direction of the inequality symbol is *reversed*.

      If $c < 0$, then $a < b$ and $ac > bc$ are equivalent inequalities.

Note the difference between Property 2a and Property 2b. Property 2a states that an equivalent inequality is produced when each side of a given inequality is multiplied (divided) by the same *positive* real number and the inequality symbol is not changed. By contrast, Property 2b states that when each side of a given inequality is multiplied (divided) by a *negative* real number we must *reverse* the direction of the inequality symbol to produce an equivalent inequality. For instance, multiplying both sides of $-b < 4$ by -1 produces the equivalent inequality $b > -4$. (We multiplied both sides of the first inequality by -1 and we changed the less than symbol to a greater than symbol.)

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If the axes are labeled as other than x and y, then we refer to the ordered pair by the given labels. For instance, if the horizontal axis is labeled t and the vertical axis is labeled d, then the ordered pairs are written as (t, d). In any case, we sometimes refer to the first number in an ordered pair as the **first coordinate** of the ordered pair and to the second number as the **second coordinate** of the ordered pair.

The graphs of the points whose coordinates are (2, 3) and (3, 2) are shown in Figure 2.3. Note that they are different points. The order in which the numbers in an ordered pair are listed is important.

TAKE NOTE

This is *very* important. An *ordered pair* is a pair of numbers, and the *order* in which the numbers are listed is important.

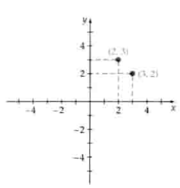

Figure 2.3

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Take Note

These margin notes alert students to a point requiring special attention or are used to highlight the concept under discussion.

Exercises

Topics for Discussion

Topics for Discussion provide questions related to key concepts of the section. Instructors can use these to initiate class discussions or to ask students to write about concepts presented in the section.

Exercises

The exercise sets of *Applied College Algebra* emphasize skill building, skill maintenance, and applications. Concept-based writing or developmental exercises have also been integrated within the exercise sets.

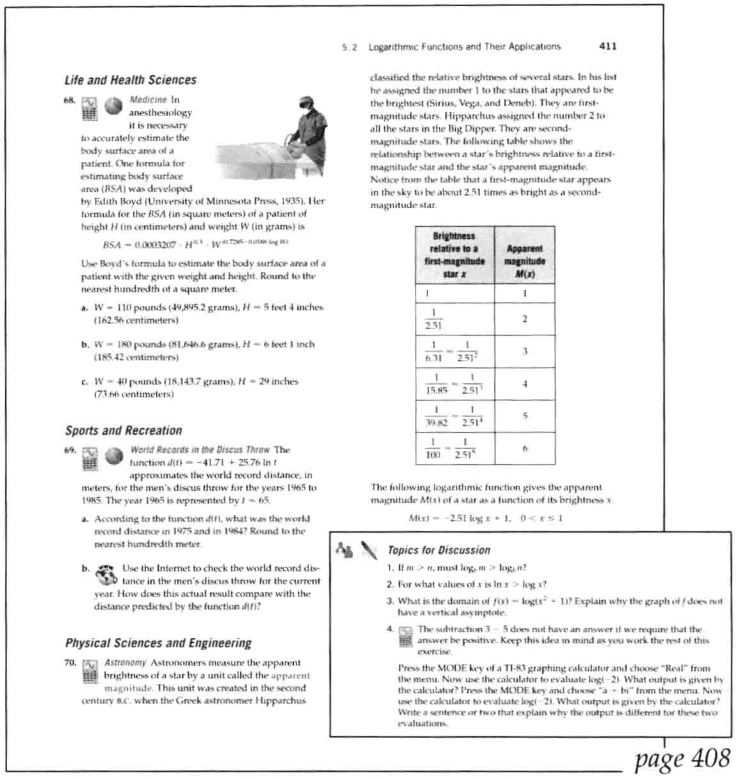
Icons identify appropriate writing, group, data analysis, and graphing calculator exercises.

Applications

Whenever possible, applications of mathematics are emphasized. Application exercises are grouped under one of five categories:

Business and Economics ***Life and Health Sciences***
Social Sciences ***Sports and Recreation***
Physical Sciences and Engineering

Each application exercise has a title that further describes the particular application.


5.2 Logarithmic Functions and Their Applications 411

Life and Health Sciences

68. *Medicine* In anesthesiology it is necessary to accurately estimate the body surface area of a patient. One formula for estimating body surface area (*BSA*) was developed by Edith Boyd (University of Minnesota Press, 1935). Her formula for the *BSA* (in square meters) of a patient of height *H* (in centimeters) and weight *W* (in grams) is

$BSA = 0.0003207 \cdot H^{0.3} \cdot W^{(0.7285 - 0.0188 \log W)}$

Use Boyd's formula to estimate the body surface area of a patient with the given weight and height. Round to the nearest hundredth of a square meter.

a. W = 110 pounds (49,895.2 grams), H = 5 feet 4 inches (162.56 centimeters)

b. W = 180 pounds (81,646.6 grams), H = 6 feet 1 inch (185.42 centimeters)

c. W = 40 pounds (18,143.7 grams), H = 29 inches (73.66 centimeters)

Sports and Recreation

69. *World Records in the Discus Throw* The function $d(t) = -41.71 + 25.76 \ln t$ approximates the world record distance, in meters, for the men's discus throw for the years 1965 to 1985. The year 1965 is represented by $t = 65$.

a. According to the function $d(t)$, what was the world record distance in 1975 and in 1984? Round to the nearest hundredth meter.

b. Use the Internet to check the world record distance in the men's discus throw for the current year. How does this actual result compare with the distance predicted by the function $d(t)$?

Physical Sciences and Engineering

70. *Astronomy* Astronomers measure the apparent brightness of a star by a unit called the apparent magnitude. This unit was created in the second century B.C. when the Greek astronomer Hipparchus classified the relative brightness of several stars. In his list he assigned the number 1 to the stars that appeared to be the brightest (Sirius, Vega, and Deneb). They are first-magnitude stars. Hipparchus assigned the number 2 to all the stars in the Big Dipper. They are second-magnitude stars. The following table shows the relationship between a star's brightness relative to a first-magnitude star and the star's apparent magnitude. Notice from the table that a first-magnitude star appears in the sky to be about 2.51 times as bright as a second-magnitude star.

Brightness relative to a first-magnitude star x	Apparent magnitude $M(x)$
1	1
$\frac{1}{2.51}$	2
$\frac{1}{6.31} = \frac{1}{2.51^2}$	3
$\frac{1}{15.85} = \frac{1}{2.51^3}$	4
$\frac{1}{39.82} = \frac{1}{2.51^4}$	5
$\frac{1}{100} = \frac{1}{2.51^5}$	6

The following logarithmic function gives the apparent magnitude $M(x)$ of a star as a function of its brightness x.

$M(x) = -2.51 \log x + 1, \quad 0 < x \le 1$

Topics for Discussion

1. If $m > n$, must $\log_b m > \log_b n$?
2. For what values of x is $\ln x > \log x$?
3. What is the domain of $f(x) = \log(x^2 + 1)$? Explain why the graph of f does not have a vertical asymptote.
4. The subtraction $3 - 5$ does not have an answer if we require that the answer be positive. Keep this idea in mind as you work the rest of this exercise.

Press the MODE key of a TI-83 graphing calculator and choose "Real" from the menu. Now use the calculator to evaluate log(−2). What output is given by the calculator? Press the MODE key and choose "a + bi" from the menu. Now use the calculator to evaluate log(−2). What output is given by the calculator? Write a sentence or two that explain why the output is different for these two evaluations.

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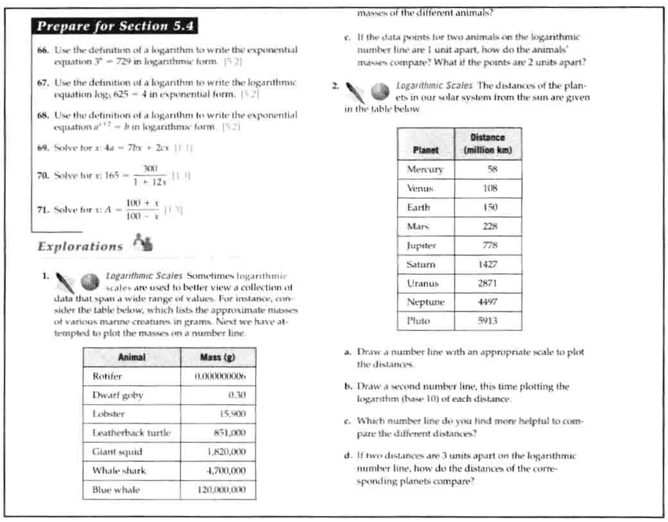
masses of the different animals?

Prepare for Section 5.4

66. Use the definition of a logarithm to write the exponential equation $3^6 = 729$ in logarithmic form. [5.2]

67. Use the definition of a logarithm to write the logarithmic equation $\log_5 625 = 4$ in exponential form. [5.2]

68. Use the definition of a logarithm to write the exponential equation $a^{x+2} = b$ in logarithmic form. [5.2]

69. Solve for x: $4a = 7bx + 2cx$ [1.1]

70. Solve for x: $165 = \frac{300}{1 + 12x}$ [1.1]

71. Solve for x: $A = \frac{100 + x}{100 - x}$ [1.1]

Explorations

1. *Logarithmic Scales* Sometimes logarithmic scales are used to better view a collection of data that span a wide range of values. For instance, consider the table below, which lists the approximate masses of various marine creatures in grams. Next we have attempted to plot the masses on a number line.

Animal	Mass (g)
Rotifer	0.000000006
Dwarf goby	0.30
Lobster	15,900
Leatherback turtle	851,000
Giant squid	1,820,000
Whale shark	4,700,000
Blue whale	120,000,000

c. If the data points for two animals on the logarithmic number line are 1 unit apart, how do the animals' masses compare? What if the points are 2 units apart?

2. *Logarithmic Scales* The distances of the planets in our solar system from the sun are given in the table below.

Planet	Distance (million km)
Mercury	58
Venus	108
Earth	150
Mars	228
Jupiter	778
Saturn	1427
Uranus	2871
Neptune	4497
Pluto	5913

a. Draw a number line with an appropriate scale to plot the distances.

b. Draw a second number line, this time plotting the logarithm (base 10) of each distance.

c. Which number line do you find more helpful to compare the different distances?

d. If two distances are 3 units apart on the logarithmic number line, how do the distances of the corresponding planets compare?

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Exercises to Prepare for the Next Section

Every section's exercise set (except for the last section of a chapter) contain exercises that allow students to practice the previously learned skills and concepts students will need to be successful in the next section. Next to each question, in brackets, is a reference to the section of the text that contains the concepts related to the question for students to easily review. All answers are provided in Answers to Selected Exercises.

Explorations are provided at the end of each exercise set and are designed to encourage students to do research and write about what they have learned. These Explorations generally emphasize critical thinking skills and can be used as collaborative learning exercises or as extra credit assignments.

End of Chapter

Chapter Summary

At the end of each chapter there is a Chapter Summary that includes **Key Terms** and **Essential Concepts and Formulas** that were covered in the chapter. These chapter summaries provide a single point of reference as the student prepares for a test. Each key term and concept references the page number from the lesson where the term or concept was first introduced.

Chapter True/False Exercises

Following each chapter summary are true/false exercises. These exercises are intended to help students understand concepts and can be used to initiate class discussions.

Chapter Review Exercises

Review exercises are found at the end of each chapter. These exercises are selected to help the student integrate all of the topics presented in the chapter.

Chapter 5 True/False Exercises

In Exercises 1 to 11, answer true or false. If the statement is false, explain why it is false or give an example to show the statement is false.

1. If $7^x = 40$, then $\log_7 40 = x$.
2. If $\log_4 x = 3.1$, then $4^{3.1} = x$.

7. A population that is growing exponentially at a continuous rate of 10% per year will double its population within 5 years.
8. If a radioactive material has a half-life of 15 days, all of the material will decay in 30 days.

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Chapter 5 Review Exercises

In Exercises 1 to 12, solve each equation. Do not use a calculator.

1. $\log_5 25 = x$
2. $\log_3 81 = x$
3. $\ln e^3 = x$
4. $\ln e^\pi = x$

17. $f(x) = 2^x - 3$
18. $f(x) = 2^{x-3}$
19. $f(x) = \frac{1}{3}\log x$
20. $f(x) = 3\log x^{1/3}$

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Chapter 5 Test

1. Evaluate *without* using a calculator: $\log_3 \frac{1}{27}$
2. Use the change-of-base formula and a calculator to approximate $\log_4 12$. Round your result to the nearest ten thousandth.

7. Write $e^{t/4} = a$ in logarithmic form.
8. Write $\log_b \frac{z^2}{y^3\sqrt{x}}$ in terms of logarithms of x, y, and z.
9. Solve $5^x = 22$. Round to the nearest ten thousandth.

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Cumulative Review Exercises

1. Solve $|x - 4| \le 2$. Write the solution set using interval notation.
2. Solve $\frac{x}{2x - 6} \ge 1$. Write the solution set using set-builder notation.

4. The height, in feet, of a ball released with an initial upward velocity of 44 feet per second and at an initial height of 8 feet is given by $h(t) = -16t^2 + 44t + 8$, where t is the time in seconds after the ball is released. Find the maximum height the ball will reach.

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CHAPTER 5 Summary 477

Chapter 5 Summary

Key Terms

acid [p. 421]
acidity of a solution [p. 420]
alkaline solution [p. 421]
apparent magnitude [p. 411]
base [p. 421]
Benford's Law [p. 412]
biological diversity [p. 452]
carbon dating [p. 446]
carrying capacity [p. 468]
catenary [p. 399]
common logarithm [p. 407]
concave upward (downward) [p. 454]
continuous growth rate [p. 440]
decibel level [p. 424]
e (base of natural exponential function) [p. 390]
exponential decay [p. 440]
exponential equation [p. 427]
exponential form [p. 401]
exponential function [p. 385]
exponential growth [p. 440]
factorial function [p. 397]
growth rate constant [p. 468]
half-life [p. 444]
inflection point [p. 472]
logarithm [p. 401]
logarithmic equation [p. 431]
logarithmic form [p. 401]
logarithmic function [p. 401]
logarithmic scale [pp. 417/426]
logistic growth model [p. 466]
Malthusian growth model [p. 466]
natural exponential function [p. 391]
natural logarithm [p. 407]
Newton's Law of Cooling [p. 446]
nomogram [p. 425]
pH of a solution [p. 421]
power function [p. 464]
p-wave [p. 419]
Richter scale magnitude of an earthquake [p. 417]
s-wave [p. 420]
zero-level earthquake [p. 417]

Essential Concepts and Formulas

- Exponential Functions
  - For $b > 0$ and $b \neq 1$, the exponential function $f(x) = b^x$ has the following properties:
    f has the set of real numbers as its domain and the set of positive real numbers as its range.
    f has a graph with a y-intercept of $(0, 1)$, and the graph passes through $(1, b)$.
    f is a one-to-one function, and the graph of f is a smooth continuous curve that is asymptotic to the x-axis.
    f is an increasing function if $b > 1$.
    f is a decreasing function if $0 < b < 1$. [p. 387]
  - As n increases without bound, $\left(1 + \frac{1}{n}\right)^n$ approaches an irrational number denoted by e. The value of e accurate to eight decimal places is 2.71828183. [p. 390]
  - The function defined by $f(x) = e^x$ is called the natural exponential function. [p. 391]
- Logarithmic Functions
  - *Definition of a Logarithm* If $x > 0$ and b is a positive constant ($b \neq 1$), then $y = \log_b x$ if and only if $b^y = x$. [p. 401]
  - The *exponential form* of $y = \log_b x$ is $b^y = x$. [p. 401]
  - The *logarithmic form* of $b^y = x$ is $y = \log_b x$. [p. 401]
  - *Basic Logarithmic Properties* [p. 402]
    $\log_b b = 1$ $\quad \log_b 1 = 0$ $\quad \log_b b^x = x$ $\quad b^{\log_b x} = x$
  - For all positive real numbers b, $b \neq 1$, the logarithmic function defined by $f(x) = \log_b x$ has the following properties:
    f has the set of positive real numbers as its domain and the set of real numbers as its range.
    f has a graph with an x-intercept of $(1, 0)$. The graph passes through $(b, 1)$.

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Chapter Test

The Chapter Test exercises are designed to simulate a possible test of the material in the chapter.

Cumulative Review Exercises

Cumulative Review Exercises, which appear at the end of each chapter (beginning with Chapter 1), allow students to refresh previously developed skills and concepts.

The answers to all Chapter Review Exercises, all Chapter Test exercises, and all Cumulative Review Exercises are given in Answers to Selected Exercises. Along with the answer, there is a reference to the section that pertains to each exercise. This further illustrates how the text supports students while they are studying and preparing for exams.

INSTRUCTOR RESOURCES

Applied College Algebra has a complete set of support materials for the instructor.

Instructor's Annotated Edition This edition contains a replica of the student text and additional items just for the instructor. These include *Instructor Notes*, *Alternative to Example* notes, *PowerPoint transparency icons*, *Suggested Assignments*, and *Answers to all exercises*.

Instructor's Solutions Manual The *Instructor's Solutions Manual* contains worked-out solutions for all exercises in the text.

Instructor's Resource Manual with Testing This resource includes a lesson plan for the *AIM for Success* student preface, four ready-to-use printed *Chapter Tests* per chapter, and a *Printed Test Bank* providing a printout of one example of each of the algorithmic items on the *HM Testing* CD-ROM program.

HM ClassPrep with HM Testing CD-ROM *HM ClassPrep* contains a multitude of text-specific resources for instructors to use to enhance the classroom experience. These resources can be easily accessed by chapter or resource type and can also link you to the text's web site. *HM Testing* is our computerized test generator and contains a database of algorithmic test items as well as providing **online testing** and **gradebook** functions.

Instructor Text-Specific Web Site The resources available on the *Class Prep CD* are also available on the instructor web site at **math.college.hmco.com/instructors**. Appropriate items are password protected. Instructors also have access to the student part of the text's web site.

STUDENT RESOURCES

Student Solutions Manual The *Student Solutions Manual* contains complete solutions to all odd-numbered exercises in the text.

Math Study Skills Workbook by Paul D. Nolting This workbook is designed to reinforce skills and minimize frustration for students in any math class, lab, or study skills course. It offers a wealth of study tips and sound advice on note taking, time management, and reducing math anxiety. In addition, numerous opportunities for self-assessment enable students to track their own progress.

HM eduSpace® Online Learning Environment *eduSpace®* is a text-specific online learning environment that combines an algorithmic tutorial program with homework capabilities. Specific content is available 24 hours a day to help you further understand your textbook.

HM mathSpace™ Tutorial CD-ROM This tutorial CD-ROM allows students to practice skills and review concepts as many times as necessary by providing algorithmically generated exercises and step-by-step solutions for practice.

SMARTHINKING™ live, online tutoring Houghton Mifflin has partnered with SMARTHINKING to provide an easy-to-use and effective online tutorial service. **Whiteboard Simulations** and **Practice Area** promote real-time visual interaction. Three levels of service are offered:

- **Text-Specific Tutoring** provides real-time, one-on-one instruction with a specially qualified "e-structor."
- **Questions Any Time** allows students to submit questions to the tutor outside the scheduled hours and receive a reply within 24 hours.
- **Independent Study Resources** connect students with around-the-clock access to additional educational services, including interactive web sites, diagnostic tests and Frequently Asked Questions posed to SMARTHINKING e-structors.

Houghton Mifflin Instructional Videos and DVDs Text-specific videos and DVDs, hosted by Dana Mosely, cover all sections of the text and provide a valuable resource for further instruction and review. Next to every objective head, the

icon serves as a reminder that the objective is covered in a video/DVD lesson.

Student Text-Specific Web Site Online student resources can be found at this text's web site at **math.college.hmco.com/students**.

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AIM for Success

Welcome to *Applied College Algebra*. As you begin this course, we know two important facts: (1) We want you to succeed. (2) You want to succeed. To do that requires an effort from each of us. For the next few pages, we are going to show you what is required of you to achieve that success and how you can use the features of this text to be successful.

Motivation

One of the most important keys to success is motivation. We can try to motivate you by offering interesting or important ways mathematics can benefit you. But, in the end, the motivation must come from you. On the first day of class, it is easy to be motivated. Eight weeks into the term, it is harder to keep that motivation.

To stay motivated, there must be outcomes from this course that are worth your time, money, and energy. List some reasons you are taking this course. Do not make a mental list—actually write them out.

TAKE NOTE

Motivation alone will not lead to success. For instance, suppose a person who cannot swim is placed in a boat, taken out to the middle of a lake, and then thrown overboard. That person has a lot of motivation to swim but there is a high likelihood the person will drown without some help. Motivation gives us the desire to learn but is not the same as learning.

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Although we hope that one of the reasons you listed was an interest in mathematics, we know that many of you are taking this course because it is required to graduate, it is a prerequisite for a course you must take, or because it is required for your major. Although you may not agree that this course is necessary, it is! If you are motivated to graduate or complete the requirements for your major, then use that motivation to succeed in this course. Do not become distracted from your goal to complete your education!

Commitment

To be successful, you must make a commitment to succeed. This means devoting time to math so that you achieve a better understanding of the subject.

List some activities (sports, hobbies, talents such as dance, art, or music) that you enjoy and at which you would like to become better.

Activity	Time Spent	Time Wished Spent

Thinking about these activities, put the number of hours that you spend each week practicing these activities next to the activity. Next to that number, indicate the number of hours per week you would like to spend on these activities.

Whether you listed surfing or sailing, aerobics or restoring cars, or any other activity you enjoy, note how many hours a week you spend doing it. To succeed in math, you must be willing to commit the same amount of time. Success requires some sacrifice.

The "I Can't Do Math" Syndrome

There may be things you cannot do, such as lift a two-ton boulder. You can, however, do math. It is much easier than lifting the two-ton boulder. When you first learned the activities you listed above, you probably could not do them well. With practice, you got better. With practice, you will be better at math. Stay focused, motivated, and committed to success.

It is difficult for us to emphasize how important it is to overcome the "I Can't Do Math" Syndrome. If you listen to interviews of very successful athletes after a particularly bad performance, you will note that they focus on the positive aspect of what they did, not the negative. Sports psychologists encourage athletes to always be positive—to have a "Can Do" attitude. Develop this attitude toward math.

Strategies for Success

Textbook Reconnaissance Right now, do a 15-minute "textbook reconnaissance" of this book. Here's how:

First, read the table of contents. Do it in three minutes or less. Next, look through the entire book, page by page. Move quickly. Scan titles, look at pictures, notice diagrams.

A textbook reconnaissance shows you where a course is going. It gives you the big picture. That's useful because brains work best when going from the general to the specific. Getting the big picture before you start makes details easier to recall and understand later on.

Your textbook reconnaissance will work even better if, as you scan, you look for ideas or topics that are interesting to you. List three facts, topics, or problems that you found interesting during your textbook reconnaissance.

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The idea behind this technique is simple: It's easier to work at learning material if you know it's going to be useful to you.

Not all the topics in this book will be "interesting" to you. But that is true of any subject. Surfers find that on some days the waves are better than others, musicians find some music more appealing than other music, computer gamers find some computer games more interesting than others, car enthusiasts find some cars more exciting than others. Some car enthusiasts would rather have a completely restored 1957 Chevrolet than a new Ferrari.

Know the Course Requirements To do your best in this course, you must know exactly what your instructor requires. Course requirements may be stated in a *syllabus*, which is a printed outline of the main topics of the course, or they may be presented orally. When they are listed in a syllabus or on other printed pages, keep them in a safe place. When they are presented orally, make sure to take complete notes. In either case, it is important that you understand them completely and follow them exactly. Be sure you know the answer to the following questions.

1. What is your instructor's name?
2. Where is your instructor's office?
3. At what times does your instructor hold office hours?

4. Besides the textbook, what other materials does your instructor require?
5. What is your instructor's attendance policy?
6. If you must be absent from a class meeting, what should you do before returning to class? What should you do when you return to class?
7. What is the instructor's policy regarding collection or grading of homework assignments?
8. What options are available if you are having difficulty with an assignment? Is there a math tutoring center?
9. Is there a math lab at your school? Where is it located? What hours is it open?
10. What is the instructor's policy if you miss a quiz?
11. What is the instructor's policy if you miss an exam?
12. Where can you get help when studying for an exam?

Remember: Your instructor wants to see you succeed. If you need help, ask! Do not fall behind. If you are running a race and fall behind by 100 yards, you may be able to catch up but it will require more effort than had you not fallen behind.

TAKE NOTE

Besides time management, there must be realistic ideas of how much time is available. There are very few people who can *successfully* work full-time and go to school full-time. If you work 40 hours a week, take 15 units, spend the recommended study time given at the right, and sleep 8 hours a day, you will use over 80% of the available hours in a week. That leaves less than 20% of the hours in a week for family, friends, eating, recreation, and other activities.

Time Management We know that there are demands on your time. Family, work, friends, and entertainment all compete for your time. We do not want to see you receive poor job evaluations because you are studying math. However, it is also true that we do not want to see you receive poor math test scores because you devoted too much time to work. When several competing and important tasks require your time and energy, the only way to manage the stress of being successful at both is to manage your time efficiently.

Instructors often advise students to spend twice the amount of time outside of class studying as they spend in the classroom. Time management is important if you are to accomplish this goal and succeed in school. The following activity is intended to help you structure your time more efficiently.

List the name of each course you are taking this term, the number of class hours each course meets, and the number of hours you should spend studying each subject outside of class. Then fill in a weekly schedule like the one on the following page. Begin by writing in the hours spent in your classes, the hours spent at work (if you have a job), and any other commitments that are not flexible with respect to the time that you do them. Then begin to write down commitments that are more flexible, including hours spent studying. Remember to reserve time for activities such as meals and exercise. You should also schedule free time.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
7–8 a.m.							
8–9 a.m.							
9–10 a.m.							
10–11 a.m.							
11–12 p.m.							
12–1 p.m.							
1–2 p.m.							
2–3 p.m.							
3–4 p.m.							
4–5 p.m.							
5–6 p.m.							
6–7 p.m.							
7–8 p.m.							
8–9 p.m.							
9–10 p.m.							
10–11 p.m.							
11–12 a.m.							

We know that many of you must work. If that is the case, realize that working 10 hours a week at a part-time job is equivalent to taking a three-unit class. If you must work, consider letting your education progress at a slower rate to allow you to be successful at both work and school. There is no rule that says you must finish school in a certain time frame.

Schedule Study Time As we encouraged you to do by filling out the time management form above, schedule a certain time to study. You should think of this time the way you would the time for work or class—that is, reasons for missing study time should be as compelling as reasons for missing work or class. "I just didn't feel like it" is not a good reason to miss your scheduled study time.

Although this may seem like an obvious exercise, list a few reasons you might want to study.

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Of course we have no way of knowing the reasons you listed, but from our experience one reason given quite frequently is "To pass the course." There is nothing wrong with that reason. If that is the most important reason for you to study, then use it to stay focused.