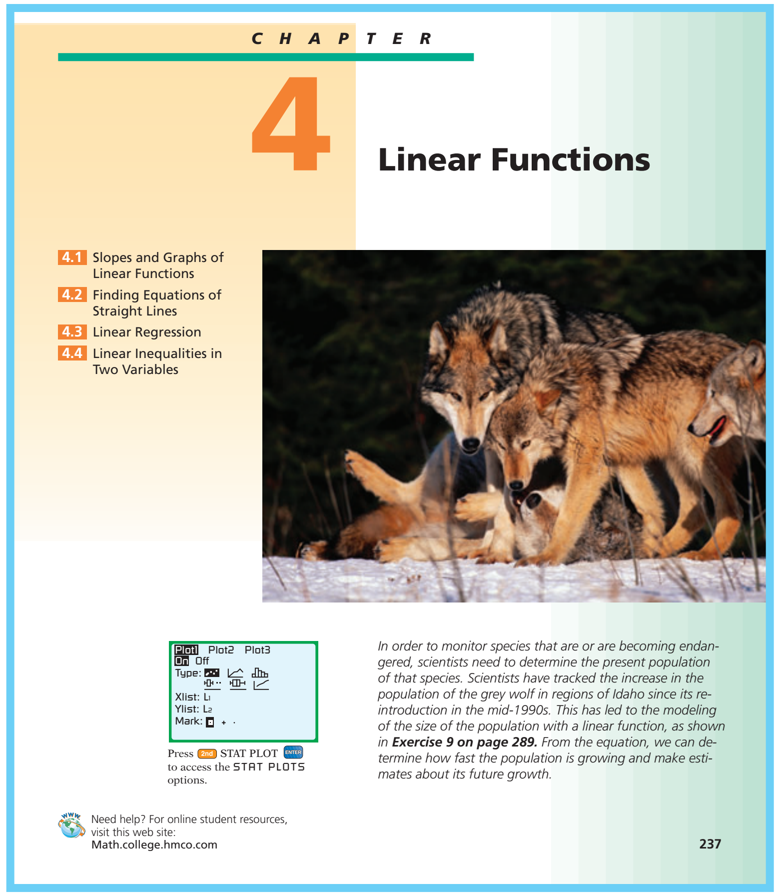

CHAPTER

4 Linear Functions

4.1 Slopes and Graphs of Linear Functions
4.2 Finding Equations of Straight Lines
4.3 Linear Regression
4.4 Linear Inequalities in Two Variables

In order to monitor species that are or are becoming endangered, scientists need to determine the present population of that species. Scientists have tracked the increase in the population of the grey wolf in regions of Idaho since its reintroduction in the mid-1990s. This has led to the modeling of the size of the population with a linear function, as shown in **Exercise 9 on page 289.** From the equation, we can determine how fast the population is growing and make estimates about its future growth.

Press STAT PLOT to access the STAT PLOTS options.

Need help? For online student resources, visit this web site: Math.college.hmco.com

237

page 237

Chapter Opener

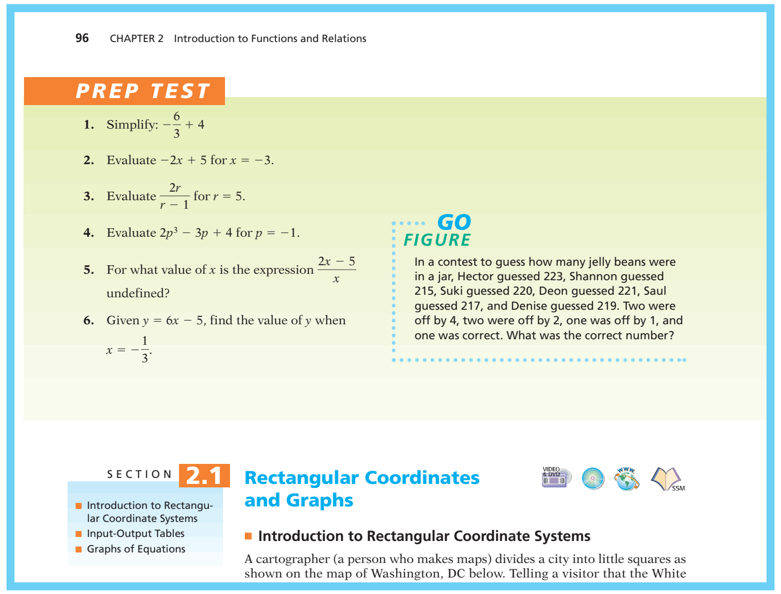
Compelling **Chapter Opening applications** illustrate a concept from the chapter. A reference to a particular exercise in the chapter then asks the student to solve a problem related to the chapter opener topic.

The [www icon] at the bottom of the page lets students know of additional online resources at **math.college.hmco.com/students**.

Prep Test and Go Figure

Prep Tests at the beginning of each chapter assess students on previously covered concepts that they must understand in order to succeed in the upcoming chapter. Answers are provided in the Answer Appendix. Section references are also provided for students who need to review specific concepts.

The **Go Figure** problem that follows the *Prep Test* is a playful puzzle problem designed to engage students in problem solving.


96 CHAPTER 2 Introduction to Functions and Relations

PREP TEST

1. Simplify: $-\frac{6}{3} + 4$
2. Evaluate $-2x + 5$ for $x = -3$.
3. Evaluate $\frac{2r}{r-1}$ for $r = 5$.
4. Evaluate $2p^3 - 3p + 4$ for $p = -1$.
5. For what value of x is the expression $\frac{2x-5}{x}$ undefined?
6. Given $y = 6x - 5$, find the value of y when $x = -\frac{1}{3}$.

GO FIGURE

In a contest to guess how many jelly beans were in a jar, Hector guessed 223, Shannon guessed 215, Suki guessed 220, Deon guessed 221, Saul guessed 217, and Denise guessed 219. Two were off by 4, two were off by 2, one was off by 1, and one was correct. What was the correct number?

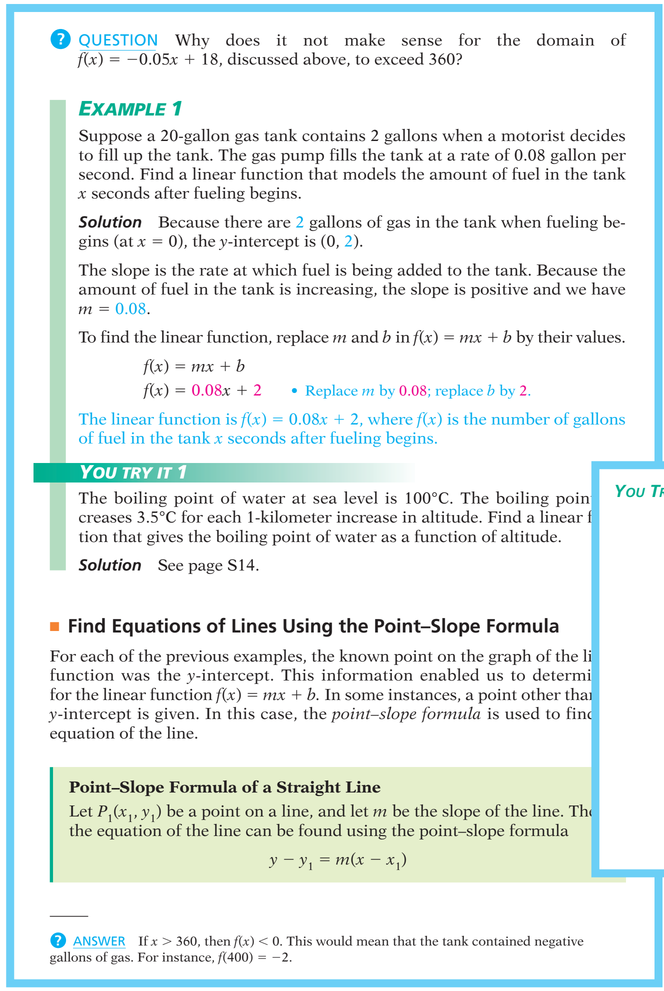
SECTION 2.1 Rectangular Coordinates and Graphs

- Introduction to Rectangular Coordinate Systems
- Input-Output Tables
- Graphs of Equations

Introduction to Rectangular Coordinate Systems

A cartographer (a person who makes maps) divides a city into little squares as shown on the map of Washington, DC below. Telling a visitor that the White

page 96


QUESTION Why does it not make sense for the domain of $f(x) = -0.05x + 18$, discussed above, to exceed 360?

EXAMPLE 1

Suppose a 20-gallon gas tank contains 2 gallons when a motorist decides to fill up the tank. The gas pump fills the tank at a rate of 0.08 gallon per second. Find a linear function that models the amount of fuel in the tank x seconds after fueling begins.

Solution Because there are 2 gallons of gas in the tank when fueling begins (at $x = 0$), the y-intercept is (0, 2).

The slope is the rate at which fuel is being added to the tank. Because the amount of fuel in the tank is increasing, the slope is positive and we have $m = 0.08$.

To find the linear function, replace m and b in $f(x) = mx + b$ by their values.

$f(x) = mx + b$
$f(x) = 0.08x + 2$ • Replace m by 0.08; replace b by 2.

The linear function is $f(x) = 0.08x + 2$, where $f(x)$ is the number of gallons of fuel in the tank x seconds after fueling begins.

YOU TRY IT 1

The boiling point of water at sea level is 100°C. The boiling poin... creases 3.5°C for each 1-kilometer increase in altitude. Find a linear f... tion that gives the boiling point of water as a function of altitude.

Solution See page S14.

Find Equations of Lines Using the Point–Slope Formula

For each of the previous examples, the known point on the graph of the li... function was the y-intercept. This information enabled us to determi... for the linear function $f(x) = mx + b$. In some instances, a point other tha... y-intercept is given. In this case, the *point–slope formula* is used to find... equation of the line.

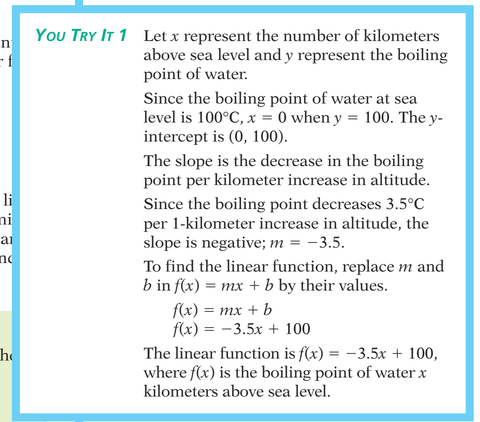
Point–Slope Formula of a Straight Line

Let $P_1(x_1, y_1)$ be a point on a line, and let m be the slope of the line. Th... the equation of the line can be found using the point–slope formula

$$y - y_1 = m(x - x_1)$$

ANSWER If $x > 360$, then $f(x) < 0$. This would mean that the tank contained negative gallons of gas. For instance, $f(400) = -2$.

page 261


YOU TRY IT 1 Let x represent the number of kilometers above sea level and y represent the boiling point of water.

Since the boiling point of water at sea level is 100°C, $x = 0$ when $y = 100$. The y-intercept is (0, 100).

The slope is the decrease in the boiling point per kilometer increase in altitude.

Since the boiling point decreases 3.5°C per 1-kilometer increase in altitude, the slope is negative; $m = -3.5$.

To find the linear function, replace m and b in $f(x) = mx + b$ by their values.

$f(x) = mx + b$
$f(x) = -3.5x + 100$

The linear function is $f(x) = -3.5x + 100$, where $f(x)$ is the boiling point of water x kilometers above sea level.

page S14

An Interactive Approach

This text's interactive approach encourages students to actively try a skill as it is presented. Each section contains one or more sets of matched-pair examples. The first example in each set is worked out; the second example, called *You Try It*, is for the student to work.

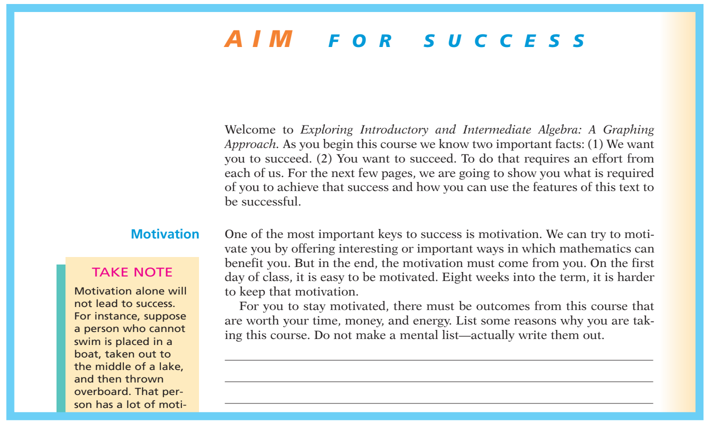
There are complete worked-out solutions to these problems in an appendix. By comparing their solution to the solution in the appendix, students obtain immediate feedback on, and reinforcement of, the concept.

Question/Answer

At various places during a discussion, the authors ask the student to respond to a **Question** about the material being read. This question encourages the reader to pause and think about the current discussion and to answer the question. To make sure the student does not miss important information, the **Answer** to the question is provided as a footnote at the bottom of the page.

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 *Exploring Introductory and Intermediate Algebra: A Graphing Approach*. 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 in which 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.

For you to stay motivated, there must be outcomes from this course that are worth your time, money, and energy. List some reasons why 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 moti-

page xxv

PROBLEM SOLVING

SECTION 4.2 Finding Equations of Straight Lines 263

YOU TRY IT 3

Find the equation of the line that passes through $P(4, 3)$ and whose slope is undefined.

Solution See page S14.

EXAMPLE 4

Judging on the basis of data from the Kelley Blue Book, the value of a certain car decreases approximately \$250 per month. If the value of the car 2 years after it was purchased was \$14,000, find a linear function that models the value of the car after x months of ownership. Use this function to find the value of the car after 3 years of ownership.

State the goal. Find a linear model that gives the value of the car after x months of ownership. Then use the model to find the value of the car after 3 years.

Devise a strategy. Because the function will predict the value of the car, let y represent the value of the car after x months.

Then $y = 14{,}000$ when $x = 24$ (2 years is 24 months).

The value of the car is decreasing \$250 per month. Therefore, the slope is -250.

Use the point–slope formula to find the linear model.

To find the value of the car after 3 years (36 months), evaluate the function when $x = 36$.

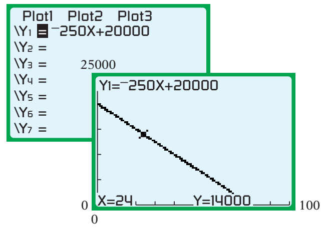
Solve the problem.

$$y - y_1 = m(x - x_1)$$
$$y - 14{,}000 = -250(x - 24)$$
$$y - 14{,}000 = -250x + 6000$$
$$y = -250x + 20{,}000$$

A linear function that models the value of the car is $V(x) = -250x + 20{,}000$.

$$f(x) = -250x + 20{,}000$$
$$f(36) = -250(36) + 20{,}000 \quad \bullet \text{ Evaluate the function at } x = 36.$$
$$= -9000 + 20{,}000$$
$$= 11{,}000$$

The value of the car is \$11,000 after 36 months of ownership.



Check your work. An answer of \$11,000 seems reasonable. This value is less than \$14,000, the value of the car after 2 years.

The graph of the function is shown at the right. Pressing TRACE 24 shows that the or-

page 263

Problem-Solving Strategies

A carefully developed approach to problem solving encourages students to develop their own strategies—drawing diagrams, for example, or writing out the solution steps in words—as part of their solution to a problem. In each case, model solutions consistently encourage students to:

State the goal.
Devise a strategy.
Solve the problem.
Check your work.

Having students describe a strategy is a natural way to incorporate writing into the math curriculum.

REAL DATA AND APPLICATIONS

EXAMPLE 5

In 2002, the computer service America Online offered its customers the option of paying \$23.90 per month for unlimited use. Another option was a rate of \$4.95 per month with 3 free hours plus \$2.50 per hour thereafter (*Source:* AOL web site, March 2002). How many hours per month can you use this second option if it is to cost you less than the first option? Round to the nearest whole number.

State the goal. The goal is to determine how many hours you can use the second option (\$4.95 per month plus \$2.50 per hour after the first 3 hours) if it is to cost you less than the first option (\$23.90 per month).

Devise a strategy. Let x represent the number of hours per month you use the service. Then $x - 3$ represents the number of hours you would be paying \$2.50 per hour for service under the second option.

Cost of first plan: 23.90

Cost of second plan: $4.95 + 2.50(x - 3)$

Write and solve an inequality that expresses that the second plan is less expensive (less than) the first plan.

Solve the problem.

$$4.95 + 2.50(x - 3) < 23.90$$
$$4.95 + 2.50x - 7.50 < 23.90$$
$$2.50x - 2.55 < 23.90$$
$$2.50x < 26.45$$
$$x < 10.58$$

The greatest whole number less than 10.58 is 10.

In order for the second option to cost you less than the first option, you can use the service for up to 10 hours per month.

Check your work. One way to check racy of our work. We can also make a p

page 207

Applications

Wherever appropriate, the last portion of a section presents applications that require the student to use problem-solving strategies, along with the skills covered in that section, to solve practical problems. This carefully integrated applied approach generates student awareness of the value of algebra as a real-life tool.

Applications are taken from many disciplines, including agriculture, business, carpentry, chemistry, construction, Earth science, education, manufacturing, nutrition, real estate, and sociology.

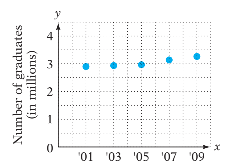
Real Data

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

Fit a Line to Data

8. *Demography* The table and scatter diagram show the projected number of U.S. high school graduates, in millions (*Source*: National Center for Education Statistics).

Year, x	'01	'03	'05	'07	'09
Number of graduates, y (in millions)	2.90	2.98	2.99	3.13	3.25



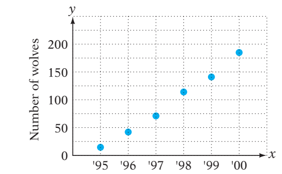
a. Find the equation of a line that approximately fits the data by selecting two data points and finding the equation of the line through those two points.

b. What does the slope of your line mean in the context of the problem?

c. What does the y-intercept mean in the context of the problem?

9. *Zoology* The table and scatter diagram show the increase in the grey wolf population in regions of Idaho after that species's re-introduction in the mid-1990s (*Source*: U.S. Fish and Wildlife Service).

Year, x	'95	'96	'97	'98	'99	'00
Number of wolves, y	14	42	71	114	141	185



a. Find the equation of a line that approximately fits the data by selecting two data points and finding the equation of the line through those two points.

b. What does the slope of your line mean in the context of the problem?

page 289

SECTION 3.4 Inequalities in One Variable 205

Example 2

Solve and graph the solution set of $7x < -21$. Write the solution set in set-builder notation and interval notation.

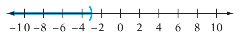
Algebraic Solution

$7x < -21$

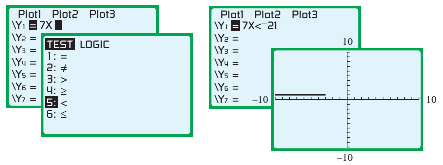
$\frac{7x}{7} < \frac{-21}{7}$ • Divide each side of the inequality by 7. Because 7 is a positive number, the inequality symbol is not reversed.

$x < -3$ • Simplify.

The solution set is $\{x|x < -3\}$ or $(-\infty, -3)$.



Graphical Check



You Try It 2

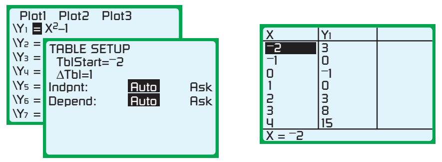
Solve and graph the solution set of $-3x \geq 6$. Write the solution set in set-builder notation and interval notation.

Solution See page S11.

page 205

See Appendix A: Y= and Table

A graphing calculator can be used to create input/output tables. The Y= key is used to enter the variable expression, and the table capabilities are used to display the table. Some typical screens for the input/output table from Example 2 follow. By using the up arrow and down arrow keys, you can view additional inputs and outputs.



CALCULATOR NOTE

For the Table Setup screen shown at the right, ΔTbl = 1. This means the change between successive values of x is 1. In mathematics, the symbol Δ is frequently used to mean "change in."

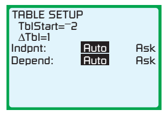
It is important to remember that **an input/output table gives ordered pairs that are solutions of an equation in two variables.** Because we entered $Y_1 = X^2 - 1$, the table at the right above shows the ordered-pair solutions of $y = x^2 - 1$. For instance, from the table, (4, 15) is a solution of $y = x^2 - 1$.

QUESTION From the table above, what is the solution of $y = x^2 - 1$ corresponding to $x = 3$?

ANSWER The output value when $x = 3$ is 8. The solution is (3, 8).

Table There are three steps in creating an input/output table for a function. First use the Y= editor to input the function. The second step is setting up the table, and the third step is displaying the table.

To set up the table, press 2nd TBLSET. TblStart is the first value of the independent variable in the input/output table. ΔTbl is the difference between successive values. Setting this to 1 means that, for this table, the input values are −2, −1, 0, 1, 2. . . . If ΔTbl = 0.5, then the input values are −2, −1.5, −1, −0.5, 0, 0.5, . . .



pages 100 and 841

Integration of Technology

We have used a TI-83/TI-83 Plus graphing calculator throughout the text to help students make connections between abstract mathematical concepts and a concrete representation provided by technology. This is one way in which students are encouraged to think about and use multiple representations of a concept.

For appropriate examples within the text, we have provided both an algebraic solution and a graphical representation of the solution. This enables the student to visualize the algebraic solution. For other graphing calculator examples, an algebraic verification of a graphing calculator solution is presented. This promotes the link between the algebraic and graphical components of a solution.

Calculator Note

These margin notes provide suggestions for using a calculator in certain situations.

Graphing Calculator Appendix A

A TI-83/TI-83 Plus graphing calculator appendix contains some of the common calculator keystrokes that are used in the text. Students are referred to this appendix by appropriately placed *See Appendix A* notes indicating which calculator feature is in use.

In addition, a convenient **calculator bookmark** containing a synopsis of major calculator functions is included in the front of the text. The calculator bookmark can be removed from the text and used to mark the student's current lesson.

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

Icons

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

Key Terms and Concepts

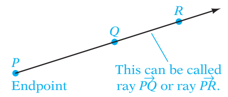
Key terms, in bold, emphasize important terms.

SECTION 3.3 Applications to Geometry

- Angles
- Intersecting Lines
- Angles of a Triangle
- Angles and Circles

Angles

A **ray** is part of a line that starts at a point, called the **endpoint** of the ray, but has no end. A ray is named by giving its endpoint and some other point on the ray. The ray below is named $\overrightarrow{PQ}$ or $\overrightarrow{PR}$.



An **angle** is formed by two rays with a common endpoint. The endpoint is the **vertex** of the angle, and the rays are the **sides of the angle.** If A is a point on one ray of an angle, C is a point on the other ray, and B is the vertex, then the angle is called $\angle B$, $\angle ABC$, or $\angle CBA$, where $\angle$ is the symbol for angle. Note that the angle is named by the vertex, or when the angle is named by giving three points, the vertex is the second point listed.

page 187

SECTION 2.2 Relations and Functions 119

For the relation between an exam score and a letter grade, the domain is all possible exam scores, and the range is all possible letter grades.

Domain = {0, 1, 2, 3, 4, . . ., 97, 98, 99, 100} and Range = {A, B, C, D, F}

Here is one more example of a relation. Consider the situation of a paleontologist trying to determine how fast a dinosaur could run. By studying the relation between the stride lengths of living creatures and the speed at which those creatures run, the scientist can infer the speed of a dinosaur. The table below shows the results of measuring the stride length and speed of various horses.

Point of Interest

Studies of foot imprints of dinosaurs suggest they traveled between 2 mph and 7 mph. However, some dinosaurs could run about 25 mph. To put this in perspective, the fastest human can run about 23.5 mph. The fastest land animal (the cheetah) can run about 65 mph.

Stride length (in meters)	2.5	3.2	2.8	3.4	3.2	3.5	4.5	5.2
Speed (in meters per second)	2.6	2.7	2.5	2.8	2.6	2.8	3.2	3.0

This relation is the set of ordered pairs {(2.5, 2.6), (3.2, 2.7), (2.8, 2.5), (3.4, 2.8), (3.2, 2.6), (3.5, 2.8), (4.5, 3.2), (5.2, 3.0)}.

QUESTION What is the meaning of the ordered pair (3.5, 2.8) for the relation above?

Although relations are important in mathematics, the concept of *function* is especially useful in applications.

TAKE NOTE

The idea of *function* is one of the most important concepts in math. It is a concept you will encounter throughout this text.

Definition of a Function

A **function** is a relation in which no two ordered pairs have the same first coordinate and different second coordinates.

The relation between stride length and speed given earlier is *not* a function because the ordered pairs (3.2, 2.7) and (3.2, 2.6) have the same first coordinate and different second coordinates.

Key Concepts are presented in green boxes in order to highlight these important concepts and to provide for easy reference.

Point of Interest

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

Take Note

These margin notes either alert students to a point requiring special attention or amplify the concept under discussion.

page 119

Annotated Examples

Examples indicated by ➡ use annotations in blue to explain what is happening in key steps of the complete, worked-out solutions.

As shown in the example that follows, the Addition Property of Inequalities applies to variable terms as well as to constants.

➡ Solve $3x - 4 \leq 2x - 1$. Write the solution set in interval notation.

$3x - 4 \leq 2x - 1$

$3x - 2x - 4 \leq 2x - 2x - 1$ • Subtract $2x$ from each side of the inequality.

$x - 4 \leq -1$ • Simplify.

$x - 4 + 4 \leq -1 + 4$ • Add 4 to each side of the inequality.

$x \leq 3$ • Simplify.

The solution set is $(-\infty, 3]$.

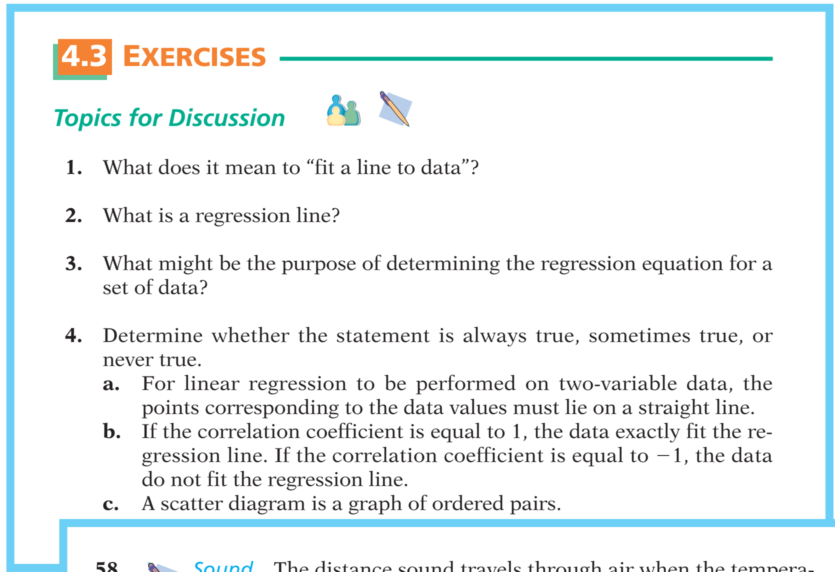
page 203

Exercises

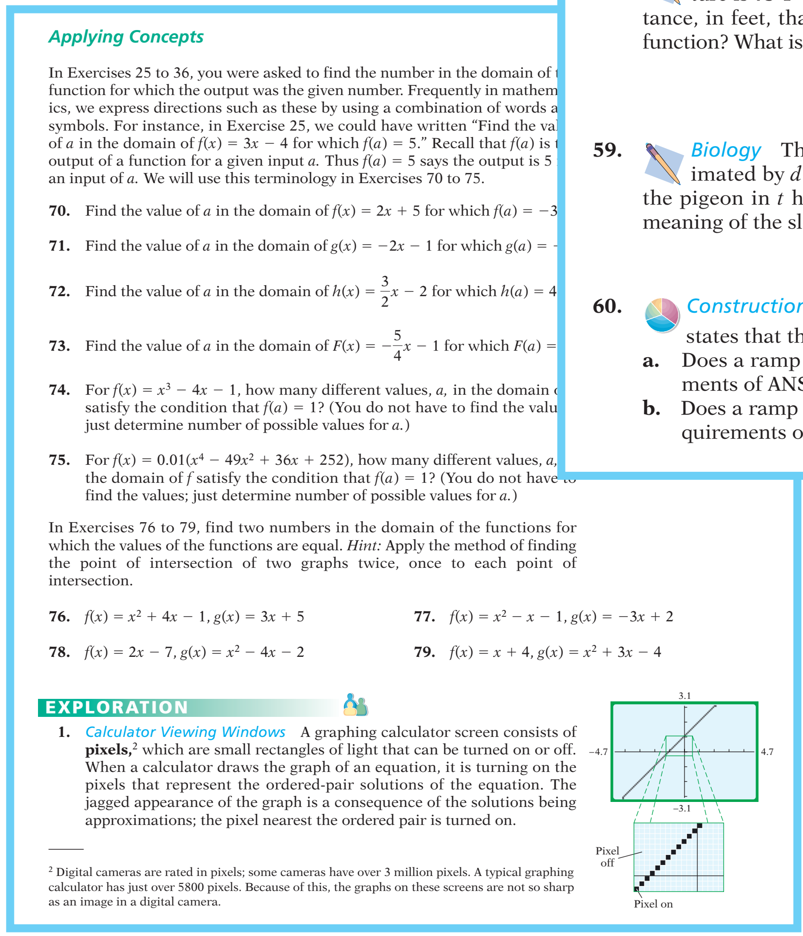
The exercise sets of *Exploring Introductory and Intermediate Algebra: A Graphing Approach* emphasize skill building, skill maintenance, and applications. Concept-based writing or developmental exercises have been integrated with the exercise sets.

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

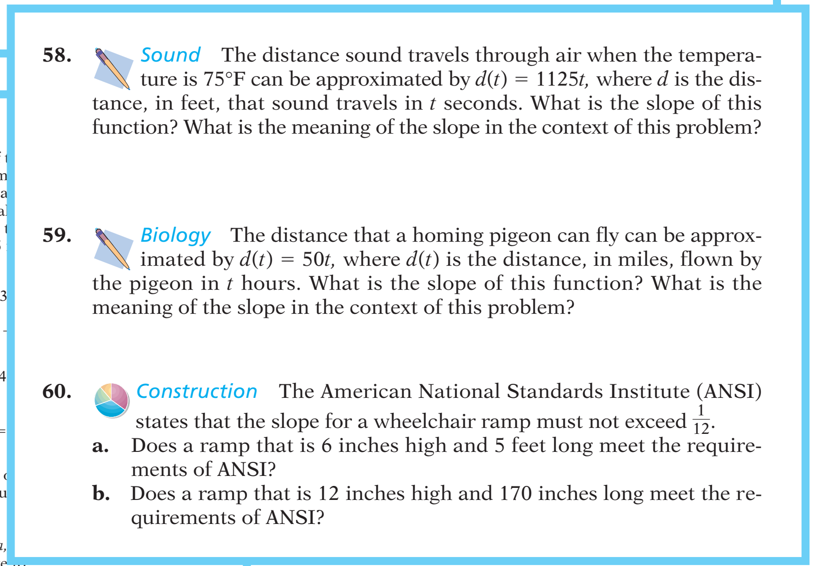
Before each exercise set are **Topics for Discussion**, which ask students to discuss or write about a concept presented in the section. Used as oral exercises, these can lead to interesting classroom discussions.



page 288



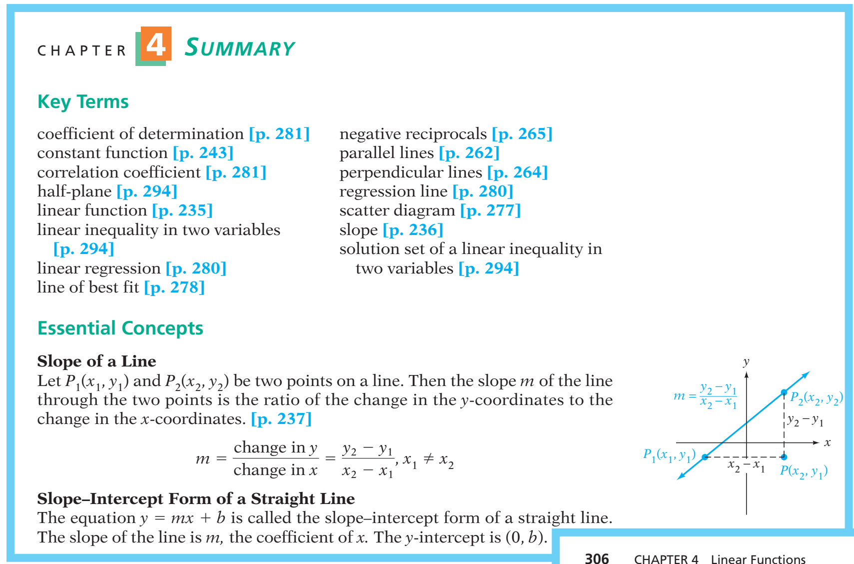
page 151



page 254

Included in each exercise set are **Applying Concepts,** which present extensions of topics, require analysis, or offer challenge problems.

Explorations are extensions of a concept presented in the section. These Explorations can be used in cooperative learning situations or as extra-credit assignments.



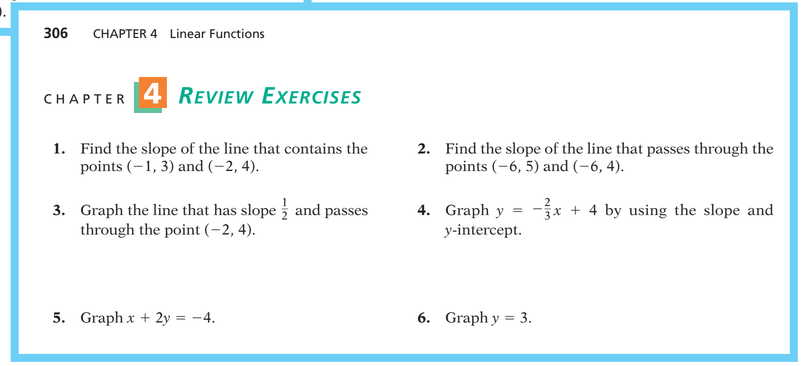
page 305

Chapter Summary

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

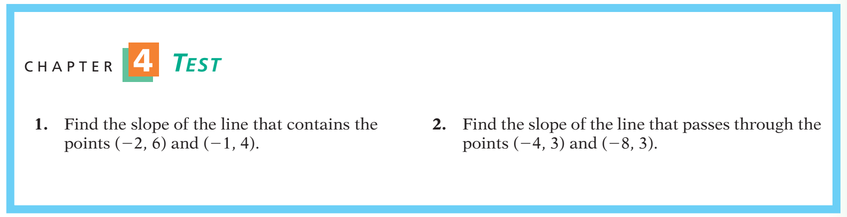
Chapter Review Exercises

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 Test

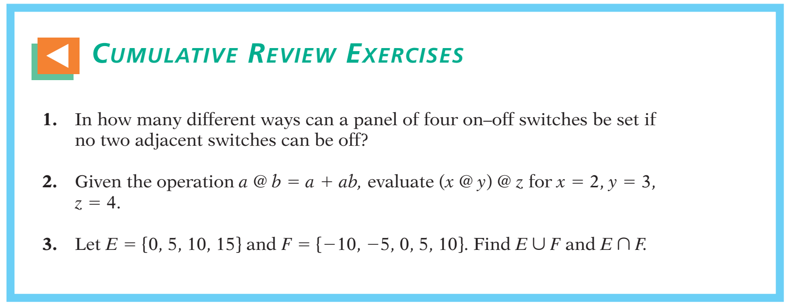
The Chapter Test exercises are designed to simulate a possible test of the material in the chapter.



Cumulative Review Exercises

Cumulative Review Exercises, which appear at the end of each chapter (beginning with Chapter 2), help students maintain skills learned in previous chapters.

The answers to all Chapter Review Exercises, all Chapter Test exercises, and all Cumulative Review Exercises are given in the Answer Section. Along with the answer, there is a reference to the section that pertains to each exercise.



pages 306, 307, 309