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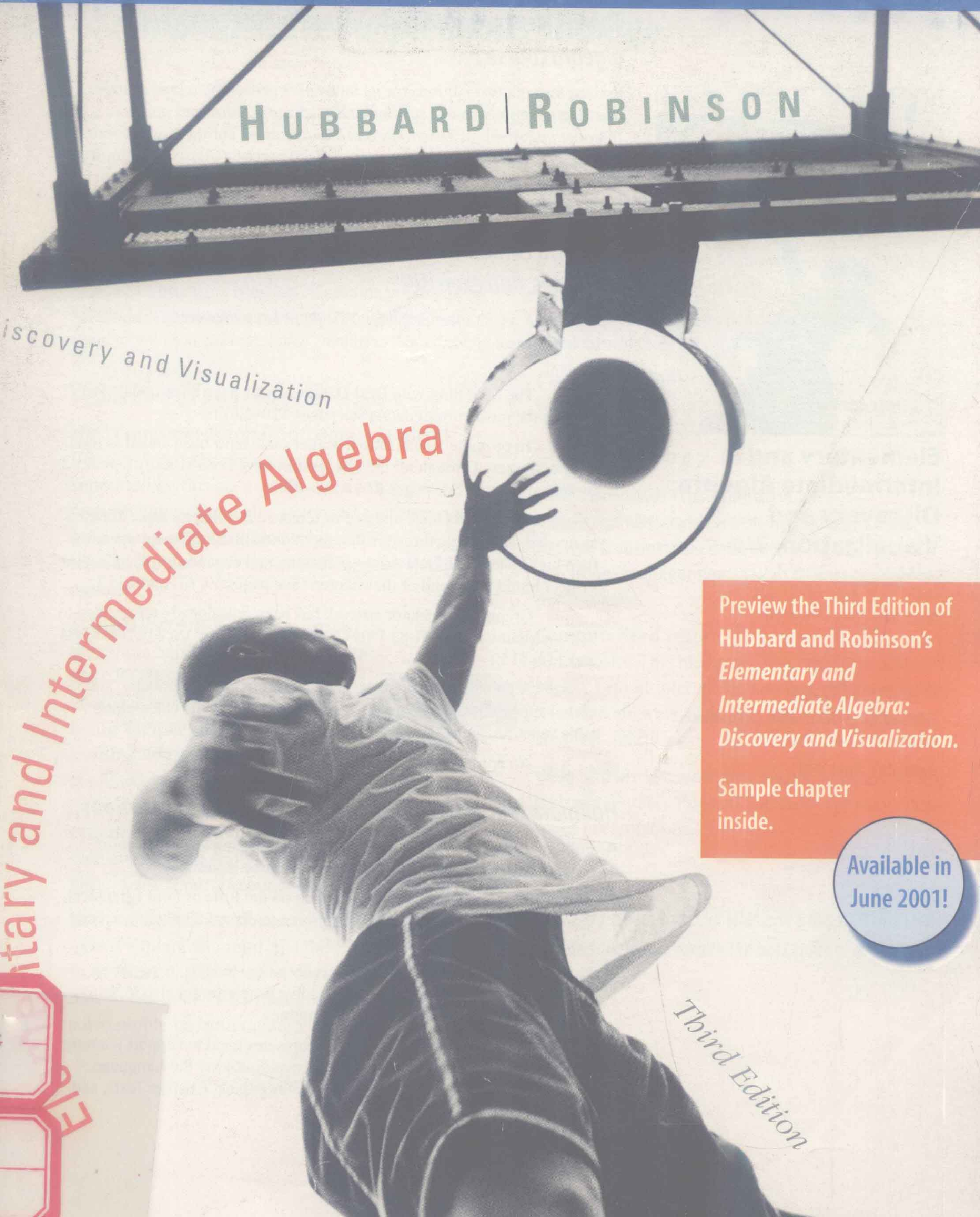

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Third Edition

Preview the Third Edition of Hubbard and Robinson's *Elementary and Intermediate Algebra: Discovery and Visualization.*

Sample chapter inside.

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Preview of

Elementary and Intermediate Algebra

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Sample Chapter

Chapter 2 Expressions and Functions

Elaine Hubbard

Kennesaw State College

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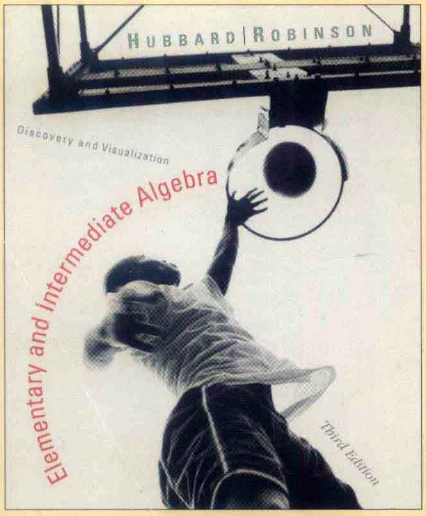
Houghton Mifflin Company Boston • New York



Elementary and Intermediate Algebra: Discovery and Visualization, 3/e

Elaine Hubbard
Kennesaw State University
Ronald D. Robinson

© 2002 • 832 Pages
Hardcover • Instructor's Annotated Edition 0-618-12992-8
Available June 2001

The first text specifically developed for the combined algebra course . . .

Praised through two editions for its innovative pedagogy, robust exercise sets, and a comprehensive supplements package, *Elementary and Intermediate Algebra: Discovery and Visualization,* Third Edition, continues to employ graphing technology as an integral part of a discovery learning approach. Developed for a one- or two-semester combined algebra course, the text thoughtfully incorporates the NCTM and AMATYC standards.

The Third Edition features up-to-date technology, examples, and exercises . . .

New! A TI-83 Plus Graphing Calculator keystroke guide is now included in an appendix and correlates with keywords used throughout the text.

New! The Modeling with Real Data exercises have been updated to provide the most current data. (See pages 129–130.)

New! To promote visualization, scatter plots have been added to modeling activities. Throughout the text, graphs have been visually enhanced for added clarity. (See pages 91 and 95–96.)

New! The authors have updated or replaced the chapter topic "threads" as needed. Each topic thread is first mentioned in the Chapter Opener, then highlighted in a Data Analysis feature, and expanded in the Chapter Project found at the end of the chapter. (See pages 59, 67, and 131.)

New! Graphing calculator artwork has been redesigned and updated to be consistent with the TI-83 Plus Graphing Calculator. (See pages 92–94 and 114–115.)

New! A greater balance of the numerical, graphical, symbolic, and verbal approaches is achieved by adding material on the calculator's table function, including the "Ask" function. (See page 90.)

New! An appendix on Conic Sections has been added.

Hallmark features provide a solid, real-world foundation . . .

- Fully integrated use of the graphing calculator complements a solid, proven, pedagogically driven delivery of course material.
- The text's multiple approaches, focusing on the Rule of Four (graphical, numerical, symbolic, and verbal) reinforce understanding while accommodating a variety of learning styles.
- Real-life applications and problems relevant to students' experience ensure that students learn not only to solve problems but also to apply mathematical concepts across the disciplines.
- End-of-section and end-of-chapter features designed to support learning include Class Discussion, Quick Reference, Speaking the Language, Chapter Projects, Review Exercises, Looking Back, Chapter Tests, and Cumulative Tests.

A comprehensive supplements package…

FOR STUDENTS

Print Supplements

Graphing Calculator Guide Contains keystroke information and examples for the TI-85, TI-86, and other models.

Student Solutions Manual Contains solutions for select odd-numbered problems from the student text.

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HM³ Computer Tutorial Software—Student Version Learning objectives in the text are supported by this state-of-the-art tutorial software, featuring algorithmically generated exercises and quizzes, animated solution steps, and lessons/problems presented in a colorful, lively manner.

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Lecture Videos Presented by Dana Mosley, these videos explain and reinforce the algebraic concepts from each chapter. In addition, students will see how to use their TI-83 Plus graphing calculator to solve problems from the text.

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*For more details on our **HM³** and **SMARTHINKING** tutorials, please turn to the back cover of this sampler.*

Here's what your colleagues are saying about the new edition of ***Elementary and Intermediate Algebra: Discovery and Visualization***

"The Hubbard/Robinson text is a very innovative, discovery oriented text. It fully integrates the technology of graphing calculators in a most appropriate and effective way. This text addresses many of the recommendations in the NCTM standards in regard to changes in the way teaching and learning take place and incorporation of the latest technology."

Kay Harelson, *Austin Peay State University*

"I was really impressed by the exercise sets. The variety of types of exercises gives students a flavor of pencil-and-paper exercises, calculator exercises, with real-world applications and modeling of data."

Nancy Brien, *Middle Tennessee State University*

"The annotated notes are prevalent and helpful, the best I have ever seen."

Scott Reed, *College of Lake County*

"I am very much in favor of the integrated technology approach of the Hubbard/Robinson text. It allows students with different learning styles to easily grasp the material.... This text [has] an excellent balance between a traditional symbolic approach and an understandable, readable reform approach."

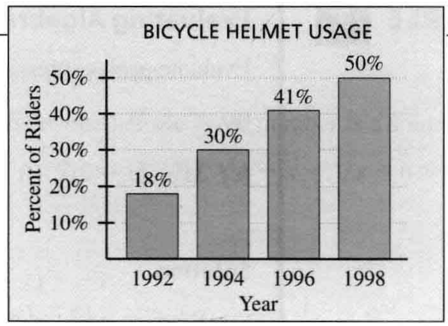
Sally Keely, *Clark College*

Chapter 2

Expressions and Functions

Real-world photos will be included in the chapter openers in the new edition.

As more and more states have enacted helmet laws for bicycle riders, the use of helmets has increased dramatically. The bar graph shows the percent of riders who wore helmets for selected years in the period 1992–1998.



(Source: U.S. Bicycle Federation.)

*We can write an **algebraic expression** to model the trend in helmet usage during this time. Using this expression, we can, for example, estimate the usage in 1997 or predict the usage in 2002. (For more on this topic, see Exercises 91–94 at the end of Section 2.1, and see the Chapter Project.)*

*In this chapter, we consider **expressions** and how to evaluate and simplify them. **Equations** and **formulas** are presented as methods for modeling conditions and relationships. We then introduce the **coordinate plane** as a model for representing ordered pairs of numbers. Finally, we define a **relation** and a **function,** and we learn how to use function notation to describe and evaluate functions.*

2.1 Algebraic Expressions and Formulas

Evaluating Algebraic Expressions • Equations and Formulas • Modeling with Real Data

Evaluating Algebraic Expressions

In the previous chapter, we described a **numerical expression** as any combination of numbers and operations. We also described a **variable** as a symbol (usually a letter) used to represent an unknown number.

We can use variables to represent numbers in expressions. An **algebraic expression** is any combination of numbers, variables, grouping symbols, and operation symbols. The following are examples of algebraic expressions.

$$x^2 + 3x - 4 \qquad \frac{a^2 + 4}{6} \qquad 5(x + 6y) - 4 \qquad r - \sqrt{2t}$$

When we replace the variables in an algebraic expression with specific values, the expression becomes a numerical expression. Performing all indicated operations to determine the value of the expression is called **evaluating the expression.**

In Example 1 we include two methods for evaluating an expression with a calculator.

Store — We assign a value to a variable by *storing* the value in the variable.

Evaluate — When we enter an algebraic expression on the home screen, the calculator will return the value of the expression for the currently stored value(s) of the variable(s).

Alpha — Special keystrokes are usually needed to enter variables other than *x*.

EXAMPLE 1

Evaluating Algebraic Expressions

Evaluate each expression for the given value(s) of the variable(s).

(a) $x^2 + 3x - 4, \quad x = -2$

(b) $5x + 2(1 - x), \quad x = -3$

(c) $3x - |y - 2x|, \quad x = 3, y = 1$

(d) $\dfrac{a + 2b}{2a^2b}, \quad a = -1, b = 3$

Solution

(a) Replace each occurrence of x with -2. Then evaluate the resulting numerical expression.

Remind students to use the correct Order of Operations.

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

(b) Replace each occurrence of x with -3.

$$5x + 2(1 - x) = 5(-3) + 2[1 - (-3)]$$

You can then enter the resulting *numerical* expression in your calculator to evaluate the expression. Figure 2.1 shows that the value of the expression is -7.

Be sure to use parentheses for calculator evaluation.

Figure 2.1

```
5(-3)+2(1-(-3))
                     -7
```

Figure 2.2

```
-3→X
                     -3
5X+2(1-X)
                     -7
```

An alternative method begins with storing -3 in the variable x. Then we enter $5x + 2(1 - x)$ to evaluate the *algebraic* expression. (See Fig. 2.2.)

(c) Replace x with 3 and y with 1.

$$3x - |y - 2x| = 3(3) - |1 - 2(3)| = 9 - |-5| = 4$$

If you use your calculator to evaluate this expression, you will need to store values for both x and y.

(d) $\dfrac{a + 2b}{2a^2b} = \dfrac{-1 + 2 \cdot 3}{2(-1)^2 \cdot 3} = \dfrac{5}{6}$

Discuss the various ways of evaluating expressions and encourage students to judge for themselves when one method is more advantageous than another.

Note: The two calculator methods illustrated in Example 1 work well when an expression is to be evaluated just once or twice. For repeated evaluation of an expression, it is better to use other techniques, which we will introduce later.

Equations and Formulas

An **equation** is a statement that two expressions have the same value. If both expressions are numerical, then the truth of the equation can be determined simply by evaluating the expressions.

If one or both sides of an equation are algebraic expressions, then the equation may be true or false, depending on the replacement for the variable. A value of the variable that makes the equation *true* is called a **solution** of the equation.

EXAMPLE 2

This is an excellent use of the TEST feature on a calculator.

Testing Solutions of an Equation

For each equation, determine whether the given number is a solution.

(a) $5 - x^2 = 3x - (2x + 1)$; 2 (b) $\sqrt{4 - x} - \sqrt{x + 6} = 2$; 3

Solution

(a)
$$\begin{aligned} 5 - x^2 &= 3x - (2x + 1) \\ 5 - 2^2 &= 3 \cdot 2 - (2 \cdot 2 + 1) && \text{Replace } x \text{ with 2.} \\ 1 &= 1 && \text{True} \end{aligned}$$

The last equation is true, so 2 is a solution.

(b)
$$\begin{aligned} \sqrt{4 - x} - \sqrt{x + 6} &= 2 \\ \sqrt{4 - 3} - \sqrt{3 + 6} &= 2 && \text{Replace } x \text{ with 3.} \\ 1 - 3 &= 2 \\ -2 &= 2 && \text{False} \end{aligned}$$

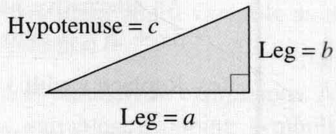
The last equation is false, so 3 is not a solution.

A **formula** is an equation that uses an expression to represent some specific quantity. For example, if the base of a triangle is b and the height is h, then the formula $A = \frac{1}{2}bh$ tells us how to determine the area A of the triangle.

An important formula is contained in the **Pythagorean Theorem.**

The Pythagorean Theorem is introduced now to prepare for the Distance Formula later.

The Pythagorean Theorem



A triangle is a right triangle if and only if the sum of the squares of the **legs** is equal to the square of the **hypotenuse.** In symbols, $a^2 + b^2 = c^2$.

We can use the formula in the Pythagorean Theorem to determine whether a triangle is a right triangle.

EXAMPLE 3

Determining Whether a Triangle Is a Right Triangle

The three numbers given in each part are the lengths of the sides of a triangle. Determine whether the triangle is a right triangle.

(a) 2, 4, 5 (b) 5, 12, 13

LEARNING TIP

When you work with the Pythagorean Theorem, it is helpful to begin by identifying the hypotenuse. It is the longest side, and it is located opposite the right angle.

Solution

(a) We must determine whether the Pythagorean Theorem formula is true for the given lengths. The longest side is 5, so $c = 5$. It does not matter how we assign the values for a and b.

$$\begin{aligned} a^2 + b^2 &= c^2 \\ 2^2 + 4^2 &= 5^2 && \text{Let } a = 2, b = 4, \text{and } c = 5. \\ 4 + 16 &= 25 \\ 20 &= 25 && \text{False} \end{aligned}$$

Ask students why the assignment of c is critical, whereas the assignments of a and b are unimportant.

The triangle is not a right triangle.

(b) The longest side is 13, so $c = 13$.

$$\begin{aligned} a^2 + b^2 &= c^2 \\ 5^2 + 12^2 &= 13^2 && \text{Let } a = 5, b = 12, \text{and } c = 13. \\ 25 + 144 &= 169 \\ 169 &= 169 && \text{True} \end{aligned}$$

The triangle is a right triangle.

Think About It

Is it necessary to use the Pythagorean Theorem to test 2, 3, and 7 to determine whether these numbers could be the lengths of the sides of a right triangle? Why?

Modeling with Real Data

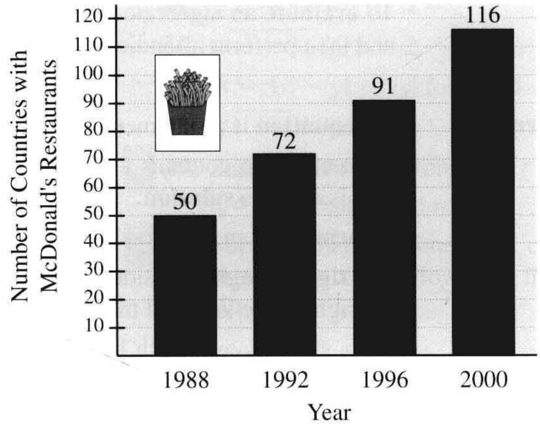
We frequently model data with an expression in which the variable represents a year. For convenience, we usually select a base year and let the variable represent the number of years after the base year.

EXAMPLE 4

McDonald's Restaurants Around the World

Figure 2.3 shows the number of countries in which McDonald's restaurants were established during the period 1988–2000. (Source: McDonald's Corporation.)

Figure 2.3



We select 1988 as our base year, and we let x represent the number of years *after* 1988. For 1988, $x = 0$; for 1992, $x = 4$; for 1996, $x = 8$; and so on.

With x defined in this way, suppose that we use the expression $5.425x + 49.7$ to *model* the number of restaurants x years after 1988.

(a) Evaluate the model expression for each year in the bar graph—that is, for $x = 0$, $x = 4$, $x = 8$, and so on. Then complete the following table. (The "Difference" column shows the difference between the actual data and the modeled data.)

Year	x	Actual	Model	Difference
1988				
1992				
1996				
2000				

(b) In what year is the model most accurate? least accurate?

Solution

(a)

Year	x	Actual	Model	Difference
1988	0	50	49.7	+0.3
1992	4	72	71.4	+0.6
1996	8	91	93.1	−2.1
2000	12	116	114.8	+1.2

(b) From the "Difference" column, we see that the model is most accurate for 1988 and least accurate for 1996.

Quick Reference 2.1

Evaluating Algebraic Expressions

- An **algebraic expression** is any combination of numbers, variables, grouping symbols, and operation symbols.
- To **evaluate** an algebraic expression, we replace each variable with a specific value and then perform all indicated operations.

Equations and Formulas

- An **equation** is a statement that two expressions have the same value.
- If an equation contains a variable, a value of the variable that makes the equation true is called a **solution.**
- A **formula** is an equation that uses an expression to represent some specific quantity.
- In a right triangle, the sides forming the right angle are called **legs;** the side opposite the right angle is called the **hypotenuse.**
- For a right triangle with legs a and b and hypotenuse c, the **Pythagorean Theorem** states that $a^2 + b^2 = c^2$.
- If the lengths of the three sides of a triangle satisfy the formula $a^2 + b^2 = c^2$, where c is the length of the longest side, then the triangle is a right triangle.

Speaking the Language 2.1

1. The longest side of a right triangle is called the ______.
2. We call $3x + 2$ a(n) ______ expression, whereas $3(5) + 2$ is an example of a(n) ______ expression.
3. A(n) ______ of an equation is any replacement for the variable that makes the equation true.
4. The sides of a right triangle are related by a rule known as the ______.

Exercises 2.1

Concepts and Skills

1. Explain why the expression $\frac{x+1}{x-2}$ cannot be evaluated for $x = 2$.

2. The expression $\frac{x-7}{7-x}$ has a value of -1 for any replacement of x except 7. Why?

In Exercises 3–18, evaluate each expression for the given value of the variable. Use your calculator only to verify your results. These are all one-variable expressions.

3. $5 - x$ for $x = -3$
4. $4 - 5x$ for $x = -2$
5. $-4x$ for $x = -1$
6. $3x - 2$ for $x = 4$
7. $5 - 3(x + 4)$ for $x = 2$
8. $x - 2(x - 1)$ for $x = -3$
9. $2x^2 - 4x - 9$ for $x = 3$
10. $x^2 - 5x$ for $x = -2$
11. $5 - |t + 3|$ for $t = -5$
12. $|3 - t| - 4$ for $t = 7$
13. $\frac{x+3}{5-x}$ for $x = 5$
14. $\frac{6}{x} + \frac{7}{x-2}$ for $x = 2$
15. $\frac{2x-3}{3-2x}$ for $x = 1$
16. $\frac{x^2-3}{x-4}$ for $x = -1$
17. $\sqrt{11 - 2x}$ for $x = 1$
18. $\sqrt{7x + 4}$ for $x = 3$

In Exercises 19–30, evaluate each expression for the given values of the variables. Use your calculator only to verify your results. Exercises 19–30 are all two-variable expressions.

19. $2x + 4y$ for $x = 3$ and $y = -2$

20. $x - y$ for $x = 4$ and $y = -3$

21. $2x - (x - y)$ for $x = 0$ and $y = -5$

22. $5 + x(x + y)$ for $x = -4$ and $y = 3$

23. $|2s - t|$ for $s = -4$ and $t = 2$

24. $5t - 2|t - s|$ for $s = 5$ and $t = 2$

25. $\dfrac{2x + y}{2x - y}$ for $x = 3$ and $y = 6$

26. $\dfrac{xy}{xy - 12}$ for $x = 4$ and $y = 3$

27. $\dfrac{2x + 3y}{x^2 + y^2}$ for $x = -6$ and $y = 4$

28. $\dfrac{xy^2}{(x + y)^2}$ for $x = 0$ and $y = -5$

29. $\dfrac{(x - 4)^2}{16} + \dfrac{(y + 2)^2}{25}$ for $x = 2$ and $y = 3$

30. $\dfrac{4y^2}{9} + \dfrac{x^2}{4}$ for $x = -2$ and $y = 6$

In Exercises 31–34, evaluate the following expression for the given values of the variables.

$$\frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

Although students are not expected to recognize the formulas in Exercises 31–38, they can still gain experience with evaluating them.

31. $a = 2$, $b = -3$, and $c = -2$

32. $a = 3$, $b = -5$, and $c = 2$

33. $a = 9$, $b = 12$, and $c = 4$

34. $a = 2$, $b = 3$, and $c = -14$

In Exercises 35–38, evaluate the following expression for the given values of the variables.

$$\frac{y_2 - y_1}{x_2 - x_1}$$

35. $x_1 = -2, x_2 = -4, y_1 = 3, y_2 = -1$

36. $x_1 = -12, x_2 = 4, y_1 = 5, y_2 = 5$

37. $x_1 = 0, x_2 = 5, y_1 = 2, y_2 = 0$

38. $x_1 = -3, x_2 = -3, y_1 = 4, y_2 = -2$

In Exercises 39–48, use your calculator to evaluate each expression for the given value(s) of the variable(s). Round decimal answers to the nearest hundredth.

39. $3x - 2$ for $x = -2.47$

40. $t^2 - 3t$ for $t = -4.56$

41. $-y + 3z$ for $y = 2.1$, $z = -3.7$

42. $m^2 - 2n^2$ for $m = -2.14$ and $n = 7.12$

43. $\sqrt{13y} + \sqrt{15x}$ for $x = 8$ and $y = 5$

44. $\sqrt{5a} - |-25b|$ for $a = 2$ and $b = 10$

45. $\sqrt{x^2 - 3x + 2}$ for $x = 2$

46. $\sqrt{x^2 - 3x}$ for $x = 2$

47. $|3 - 5x| - |4 - 7y|$ for $x = 4$ and $y = 2$

48. $\sqrt{1 - x}$ for $x = -5$

49. Suppose that you store 5 in t and then you evaluate $\sqrt{4 - t}$. Explain the result.

50. Suppose that someone turns on your calculator and presses the X key. How does the calculator respond? Why?

In Exercises 51–56, suppose that you store 5 for x. What value would you need to store for y in order for each of the following expressions to have a value of 9? Use your calculator to verify your answers.

51. $x + y$ **52.** $x - y$ **53.** xy

54. $\dfrac{y}{x}$ **55.** $|y - x|$ **56.** y

57. Explain the difference between evaluating an expression and verifying that a number is a solution of an equation.

58. Explain how to determine which member of the set $A = \{-8, -1, 0, 2.3, 8, 37.92\}$ is a solution of the equation $3 \cdot (2x) = (3 \cdot 2)x$ without substituting any of the numbers in set A.

In Exercises 59–64, determine which member of the following set is a solution of the given equation.

$$\left\{-5, -3, -\frac{1}{2}, 2, \frac{5}{2}, 4\right\}$$

59. $7 - 3x = 1$

60. $2x + 3 = 2$

61. $3x - 7 = 5$

62. $5 - x = 8$

63. $13 - 4x = 3$

64. $3x + 17 = 2$

In Exercises 65–72, for each of the equations, determine whether the given number is a solution.

Encourage students to use a variety of methods, including evaluating both sides and using the TEST feature of the calculator.

65. $3x - 12 = -3(4 - x)$; 0

66. $x - 7 = 7 - x$; 2

67. $x(x - 3) = 2$; 2

68. $(x - 5)(x + 2) = 0;\ -2$

69. $x^2 - x - 6 = 0;\ -2$

70. $2x^2 - 7x + 3 = 0;\ 1$

71. $\frac{x}{2} - 3 = 5;\ 4$

72. $\frac{x}{3} + \frac{x}{6} = \frac{3}{2};\ 3$

Geometric Models

Exercises 73–80 provide another opportunity to use the TEST feature of the calculator.

In Exercises 73–80, the three given numbers are the lengths of the sides of a triangle. Determine whether the triangle is a right triangle.

73. 5, 7, 4

74. 12, 13, 17

75. 17, 8, 15

76. 24, 25, 7

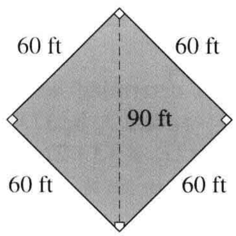
77. 9, 12, 15

78. 25, 24, 10

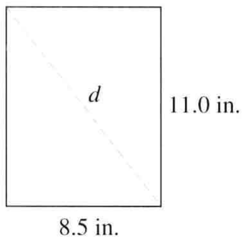
79. $1, 1, \sqrt{2}$

80. $1, 2, \sqrt{3}$

81. Some community volunteers have laid out a softball field at the local park. The distance between the bases is 60 feet. The distance from home plate to second base is 90 feet. (See figure.) Is the infield perfectly square? If not, what should be the distance from home plate to second base (to the nearest tenth)?



82. Standard letter paper is 8.5 inches wide and 11 inches long. To the nearest tenth, what is the diagonal distance d across the paper? (See figure.)



83. A building inspector is checking on an apartment building that is under construction. She finds that a window ledge, exactly 22 feet from the level ground, can be reached with a ladder that is 24 feet long. (See figure.) The bottom of the ladder is 6 feet away from the base of the wall, and the top of the ladder just reaches the window ledge. Is the wall perfectly vertical? Explain.

Figure for 83

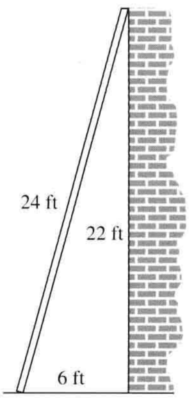
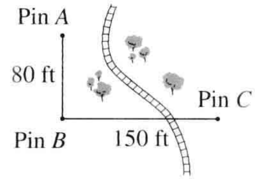


Figure for 84



84. **Perpendicular lines** are lines that intersect to form right angles. A surveyor places pins at three corners of a property. (See figure.) The distance along one side of the property is 80 feet, and the distance along the other side is 150 feet. Explain what measurement the surveyor can use to determine whether the two sides of the property are perpendicular. What should the measurement be?

Real-Life Applications

85. A tourist is planning a January trip from his home in London to San Francisco. To plan his wardrobe, he learns that the average January temperature is 50°F. To convert to Celsius, the temperature scale in England, he uses the formula $C = \frac{5}{9}(F - 32)$. What is the corresponding Celsius temperature?

86. A radio station in Toronto, Canada, reports that the current temperature is $-10°$. Listeners who live in Buffalo, New York, know that this is a Celsius temperature. To convert to Fahrenheit, they use the formula $F = \frac{9}{5}C + 32$. What is the Fahrenheit temperature?

87. At a simple interest rate r, an investment of P dollars will grow to an amount A in t years according to the formula $A = P + Prt$. If a college fund of \$1000 is invested at 6% simple interest, what will be the value of the investment after 5 years?

88. To signal the beginning of a yacht race, a flare is shot into the air. The height h (in feet) of the flare after t seconds is given by $h = 112t - 16t^2$. Determine the height of the flare after (a) 3.5 seconds and (b) 6 seconds.

Modeling with Real Data

89. The accompanying table shows the record high and low temperatures for selected states.

State	High (in °F)	Low (in °C)
Hawaii	100	−10
Oklahoma	121	−40
Florida	109	−19
Wisconsin	114	−48

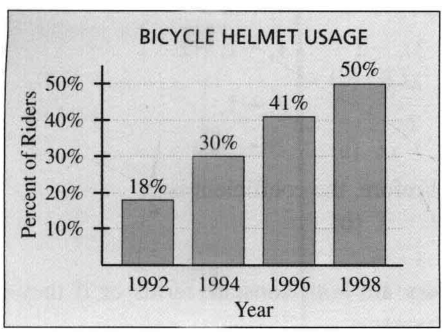
(Source: National Oceanic and Atmospheric Administration.)

Create a table with the headings "State," "High (in °C)," and "Low (in °F)." Then use the formulas $C = \frac{5}{9}(F - 32)$ and $F = \frac{9}{5}C + 32$ to fill in the table with the corresponding Fahrenheit F temperatures or Celsius C temperatures. Round results to the nearest tenth.

90. The number of letter carriers who were bitten by dogs decreased from 2787 in 1994 to 2541 in 1998. (Source: U.S. Postal Service.) With x representing the number of years since 1998, the expression $-61.5x + 2541$ is a model for the number of letter carriers who were bitten in year x. (Note that $x = -4$ for 1994.) Use the model to estimate the number of letter carriers who were bitten in 1996.

Data Analysis: *Bicycle Helmet Usage*

As more and more states have enacted helmet laws for bicycle riders, the use of helmets has increased dramatically. The bar graph shows the percent of riders who wore helmets for selected years in the period 1992–1998. (Source: U.S. Bicycle Federation.)



If we let t represent the number of years after 1992, then the percent of riders who wore helmets can be modeled by the expression $5.35t + 18.7$.

91. What values should we substitute for t in order to obtain approximations of the percentages in the bar graph?

92. If you evaluate the model expression for $t = 10$, what is your interpretation of the result?

93. The bar graph does not give data for 1997. Use the model to estimate the percent for that year.

94. What is the value of the model expression when $t = 16$? What does the result suggest about the validity of the model in the long-term future?

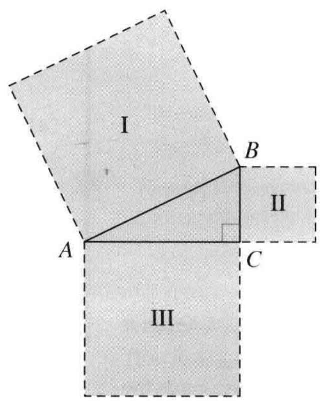
Challenge

95. The following equations illustrate sets of three integers that satisfy the Pythagorean Theorem formula $a^2 + b^2 = c^2$.

$$3^2 + 4^2 = 5^2$$
$$5^2 + 12^2 = 13^2$$
$$7^2 + 24^2 = 25^2$$
$$9^2 + 40^2 = ?$$

What pattern is revealed by these equations? Write the next two equations in the list and use your calculator to verify that they satisfy the Pythagorean Theorem formula.

96. In the accompanying figure, ΔABC is a right triangle. Squares I, II, and III are drawn so that one side of each square is also a side of the triangle. Explain how the area of Square I is related to the areas of the other two squares. (*Hint:* Consider the Pythagorean Theorem.)



2.2 Simplifying Expressions

Terms and Coefficients • Simplifying Algebraic Expressions • Translations

Terms and Coefficients

We refer to the addends of an algebraic expression as **terms.** A term with no variable is called a **constant term.**

Because the expression $6x^2 - 8x + 7$ can be written as $6x^2 + (-8x) + 7$, the terms are $6x^2$, $-8x$, and 7. The constant term is 7. Because $x + y$ can be written as $x + y + 0$, the constant term is 0.

Grouping symbols can affect the number of terms of an expression.

Expression	*Terms*
$x^2 + 5x + 3$	Three terms: x^2, $5x$, 3
$x^2 + 5(x + 3)$	Two terms: x^2, $5(x + 3)$

Note: An easy way to identify the terms of an expression is to determine the parts of the expression that are separated by plus or minus signs that are not inside grouping symbols.

Recall that in an expression such as $5xy$, the factors are 5, x, and y. The numerical factor in a term is called the **numerical coefficient,** or simply the **coefficient.** Thus the coefficient of $5xy$ is 5. If the coefficient is not specifically indicated, it is understood to be 1 or -1.

Term	*Coefficient*	
y	1	Multiplicative Identity Property: $y = 1y$
$-ab$	-1	Multiplication Property of -1: $-ab = -1ab$

EXAMPLE 1

Identifying Terms and Coefficients

Identify the terms and coefficients in each expression.

	Expression	*Terms*	*Coefficients*
(a)	$4a^2 - 3a + 5$	$4a^2, -3a, 5$	$4, -3, 5$
(b)	$y - (x - 3) - 2$	$y, -(x - 3), -2$	$1, -1, -2$
(c)	$3y - x + \dfrac{y-5}{2}$	$3y, -x, \dfrac{y-5}{2}$	$3, -1, \dfrac{1}{2}$

Note that $\dfrac{y-5}{2} = \dfrac{1}{2}(y - 5)$. Therefore, the coefficient is $\dfrac{1}{2}$.

Discuss why $-(x - 3)$ and $\dfrac{y-5}{2}$ are considered terms. This concept is important for factoring by grouping.

Think About It

In the expression $5[(x + y + 2) - 7]$, how many terms are inside the parentheses? inside the brackets? in the entire expression?

Two terms are called **like terms** if they are both constant terms or if they have the same variable factors with the same exponents.

Like Terms	*Unlike Terms*
$2x$, $7x$	$2x$, 7
$5y$, $3y$	$5y$, $3y^2$
$3a^2b$, $6a^2b$	$3a^2b$, $6ab^2$

Simplifying Algebraic Expressions

Equivalent expressions are expressions that have the same defined value regardless of the replacements for the variables. Two expressions may be equivalent even though some replacements for the variable are not permitted. For example, the expressions $\frac{x}{x}$ and 1 are equivalent because they have the same value for any replacement of x except 0.

To **simplify** an algebraic expression, we remove grouping symbols and combine like terms. The result is an expression that is equivalent to the original expression.

Combining like terms is accomplished by applying the Distributive Property.

$$3a + 5a = a(3 + 5) = a \cdot 8 = 8a$$

Because the Commutative Property of Multiplication allows us to write factors in any order, we can save a step when we combine like terms. For example,

$$6n^2 - 7n^2 = (6 - 7)n^2 = -1n^2 = -n^2$$

EXAMPLE 2

Eventually students should be encouraged to perform the middle step mentally.

Combining Like Terms

(a) $2y - 3 - 5y + 1 = (2 - 5)y + (-3 + 1) = -3y - 2$

(b) $2a^2 + b - 2b - a^2 = (2 - 1)a^2 + (1 - 2)b = a^2 - b$

(c) $a^2b - ab^2 + 3a^2b - 5ab^2 = 4a^2b - 6ab^2$

We can also use the Distributive Property to remove certain grouping symbols. An expression of the form $a(b + c)$ is equivalent to the expression $ab + ac$.

An expression of the form $-(b + c)$ is equivalent to the expression $-1(b + c)$, which is equivalent to $-b - c$. In effect, the opposite sign in front of the group has the effect of changing the sign of each term inside the group.

EXAMPLE 3

These examples require careful attention to signs.

Simplifying Algebraic Expressions

(a) $(3 + 4x) - (5x - 1) = 3 + 4x - 5x + 1$ Remove parentheses.
$= -x + 4$ Combine like terms.

(b) $2(3x^2 - 2) - 3(x + 5) = 6x^2 - 4 - 3x - 15$ Distributive Property
$= 6x^2 - 3x - 19$ Combine like terms.

(c) $3x + x(5 - x) - 7x = 3x + 5x - x^2 - 7x$ Distributive Property
$= -x^2 + x$ Combine like terms.

(d) $7 - 3[4 - (x - 2)] = 7 - 3[4 - x + 2]$ Remove parentheses.
$= 7 - 3[6 - x]$ Combine like terms.
$= 7 - 18 + 3x$ Remove brackets.
$= -11 + 3x$ Combine like terms.

Translations

Students will be given much practice with translating throughout this book.

We can think of a *model* as a representation of an object, an idea, or information. When we use algebra to solve problems, it is often necessary to write the given information as an algebraic expression or equation that symbolically models the conditions of the problem and the operations to be performed.

The following are some typical translations involving the four basic operations.

Addition

Phrase	*Expression*
a number added to 5	$x + 5$
a number increased by 8	$x + 8$
7 more than a number	$x + 7$
the sum of two numbers	$x + y$

Subtraction

The order in subtraction is often a problem for students.

Phrase	*Expression*
-3 subtracted from a number	$x - (-3)$
a number decreased by 7	$x - 7$
6 less than a number	$x - 6$
the difference between 8 and a number	$8 - x$

Multiplication

Phrase	*Expression*
a number multiplied by -4	$-4x$
two-thirds of a number	$\frac{2}{3}x$
the product of two numbers	xy
twice a number	$2x$
6% of a number	$0.06x$

Division

Phrase	*Expression*
the quotient of -3 and a number	$\frac{-3}{x}$
the ratio of two numbers	$\frac{x}{y}$
a number divided by 5	$\frac{x}{5}$

When we translate information into an equation, we watch for words such as *is, equals, obtain,* and *results in,* which correspond to the equality symbol.