

# Chapter 9

## Prerequisite Skills (p. 552)

- Terms that have the same variable part are called *like terms*.
- For a function  $f(x)$  a zero is an  $x$ -value for which  $f(x) = 0$ .
- Factors of 121: 1, 11, 121  
Factors of 77: 1, 7, 11, 77  
The GCF is 11.
- Factors of 96: 1, 2, 3, 4, 6, 8, 12, 16, 24, 32, 48, 96  
Factors of 32: 1, 2, 4, 8, 16, 32  
The GCF is 32.
- Factors of 81: 1, 3, 9, 27, 81  
Factors of 42: 1, 2, 3, 6, 7, 14, 21, 42  
The GCF is 3.
- Factors of 12: 1, 2, 3, 4, 6, 12  
Factors of 56: 1, 2, 4, 7, 8, 14, 28, 56  
The GCF is 4.
- $3x + (-6x) = 3x - 6x = -3x$
- $5 + 4x + 2 = 4x + 7$
- $4(2x - 1) + x = 8x - 4 + x = 9x - 4$
- $-(x + 4) - 6x = -x - 4 - 6x = -7x - 4$
- $(3xy)^3 = 3^3x^3y^3 = 27x^3y^3$
- $xy^2 \cdot xy^3 = x^{1+1}y^{2+3} = x^2y^5$
- $(x^5)^3 = x^{15}$       14.  $(-x)^3 = (-1)^3 \cdot x^3 = -x^3$

## Lesson 9.1

### 9.1 Guided Practice (pp. 555–556)

- $5y - 2y^2 + 9 = -2y^2 + 5y + 9$   
The greatest degree is 2, so the degree of the polynomial is 2, and the leading coefficient is  $-2$ .
- $y^3 - 4y + 3$  is a polynomial because each of its terms has whole number exponents. The greatest degree is 3, so the degree of the polynomial is 3. There are 3 terms, so the polynomial is a trinomial.
- $(5x^3 + 4x - 2x) + (4x^2 + 3x^3 - 6)$   
 $= (5x^3 + 3x^3) + 4x^2 + (4x - 2x) - 6$   
 $= 8x^3 + 4x^2 + 2x - 6$
- $\frac{(4x^2 - 7x)}{-(5x^2 + 4x - 9)} \rightarrow \frac{4x^2 - 7x}{-5x^2 - 4x + 9}$   
 $\frac{-x^2 - 11x + 9}{-x^2 - 11x + 9}$
- $N - A = (-488t^2 + 5430t + 24,700)$   
 $- (-318t^2 + 3040t + 25,600)$   
 $= -488t^2 + 5430t + 24,700 + 318t^2$   
 $- 3040t - 25,600$   
 $= (-488t^2 + 318t^2) + (5430t - 3040t)$   
 $+ (24,700 - 25,600)$   
 $= -170t^2 + 2390t - 900$   
For 2001, let  $t = 6$ :  
 $N - A = -170(6)^2 + 2390(6) - 900 = 7320$

The difference in attendance at National and American League baseball games in 2001 was 7,320,000 people.

### 9.1 Exercises (pp. 557–559)

#### Skill Practice

- A number, a variable, or the product of one or more variables is called a *monomial*.
- Yes; polynomial is a monomial or a sum of monomials. Because 6 is a monomial, it is also a polynomial.
- $9m^5$       4.  $2 - 6y = -6y + 2$   
Degree: 5      Degree: 1  
Leading coefficient: 9      Leading coefficient:  $-6$
- $2x^2y^2 - 8xy$       6.  $5n^3 + 2n - 7$   
Degree: 4      Degree: 3  
Leading coefficient: 2      Leading coefficient: 5
- $5z + 2z^3 - z^2 + 3z^4 = 3z^4 + 2z^3 - z^2 + 5z$   
Degree: 4      Leading coefficient: 3
- $-2h^2 + 2h^4 - h^6 = -h^6 + 2h^4 - 2h^2$   
Degree: 6      Leading coefficient:  $-1$
- C;  $-4x^3 + 6x^4 - 1 = 6x^4 - 4x^3 - 1$   
The greatest degree is 4, so the degree of the polynomial is 4.
- D;  $3s^{-2}$  has an exponent that is not a whole number.
- $-4^x$  is not a polynomial because it has a variable exponent.
- $w^{-3} + 1$  is not a polynomial because not all of the exponents are whole numbers.
- $3x - 5$  is a polynomial that is a first degree binomial.
- $\frac{4}{5}f^2 - \frac{1}{2}f + \frac{2}{3}$  is a polynomial that is a second degree trinomial.
- $6 - n^2 + 5n^3$  is a polynomial that is a third degree trinomial.
- $10y^4 - 3y^2 + 11$  is a polynomial that is a fourth degree trinomial.
- $\frac{5a^2 - 3}{+ 8a^2 - 1}$   
 $\frac{13a^2 - 4}{13a^2 - 4}$
- $(h^2 + 4h - 4) + (5h^2 - 8h + 2)$   
 $= (h^2 + 5h^2) + (4h - 8h) + (-4 + 2)$   
 $= 6h^2 - 4h - 2$
- $\frac{4m^2 - m + 2}{+ -3m^2 + 10m + 7}$       20.  $\frac{7k^2 + 2k - 6}{+ 3k^2 - 11k - 8}$   
 $\frac{m^2 + 9m + 9}{m^2 + 9m + 9}$        $\frac{10k^2 - 9k - 14}{10k^2 - 9k - 14}$
- $(6c^2 + 3c + 9) - (3c - 5) = 6c^2 + 3c + 9 - 3c + 5$   
 $= 6c^2 + (3c - 3c) + (9 + 5) = 6c^2 + 14$
- $(3x^2 - 8) - (4x^3 + x^2 - 15x + 1)$   
 $= 3x^2 - 8 - 4x^3 - x^2 + 15x - 1$   
 $= -4x^3 + (3x^2 - x^2) + 15x + (-8 - 1)$   
 $= -4x^3 + 2x^2 + 15x - 9$

## Chapter 9, continued

23. 
$$\frac{(-n^2 + 2n)}{-(2n^3 - n^2 + n + 12)} \rightarrow \frac{-n^2 + 2n}{-2n^3 + n^2 - n - 12}$$
  

$$= \frac{-n^2 + 2n}{-2n^3 + n - 12}$$
24. 
$$\frac{(9b^3 - 13b^2 + b)}{-( -13b^2 - 5b + 14)} \rightarrow \frac{9b^3 - 13b^2 + b}{9b^3 + 13b^2 + 5b - 14}$$
  

$$= \frac{9b^3 + 6b - 14}{9b^3 + 13b^2 + 5b - 14}$$
25. 
$$(4d - 6d^3 + 3d^2) - (9d^3 + 7d - 2)$$
  

$$= 4d - 6d^3 + 3d^2 - 9d^3 - 7d + 2$$
  

$$= (-6d^3 - 9d^3) + 3d^2 + (4d - 7d) + 2$$
  

$$= -15d^3 + 3d^2 - 3d + 2$$
26. 
$$(9p^2 - 6p^3 + 3 - 11p) + (7p^3 - 3p^2 + 4)$$
  

$$= (-6p^3 + 7p^3) + (9p^2 - 3p^2) - 11p + (3 + 4)$$
  

$$= p^3 + 6p^2 - 11p + 7$$
27. The like terms in the trinomials were not aligned, so the terms were added incorrectly.
- $$\begin{array}{r} x^3 - 4x^2 + 3 \\ + -3x^3 + 8x - 2 \\ \hline -2x^3 - 4x^2 + 8x + 1 \end{array}$$
28. The negative sign wasn't distributed in the second polynomial before the terms were grouped.
- $$(6x^2 - 5x) - (2x^2 + 3x - 2)$$
- 
- $$= 6x^2 - 5x - 2x^2 - 3x + 2$$
- 
- $$= (6x^2 - 2x^2) + (-5x - 3x) + 2$$
- 
- $$= 4x^2 - 8x + 2$$
29. 
$$f(x) + g(x) = (3x^2 + x - 7) + (-x^2 + 5x - 2)$$
  

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

$$= 2x^2 + 6x - 9$$
  

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

$$= 3x^2 + x - 7 + x^2 - 5x + 2$$
  

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

$$= 4x^2 - 4x - 5$$
30. 
$$p(x) = (2x + 6) + (x + 8) + (9x - 6)$$
  

$$= (2x + x + 9x) + (6 + 8 - 6)$$
  

$$= 12x + 8$$
31. 
$$p(x) = (2x) + (3x - 2) + (2x + 1) + (5x - 2)$$
  

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

$$= 12x - 3$$
32. 
$$(3r^2s + 5rs + 3) + (-8rs^2 - 9rs - 12)$$
  

$$= 3r^2s - 8rs^2 + (5rs - 9rs) + (3 - 12)$$
  

$$= 3r^2s - 8rs^2 - 4rs - 9$$
33. 
$$\frac{x^2 + 11xy - 3y^2}{+ -2x^2 - xy + 4y^2}$$
  

$$\frac{-x^2 + 10xy + y^2}{-x^2 + 10xy + y^2}$$
34. 
$$\frac{(5mn + 3m - 9n)}{-(13mn + 2m)} \rightarrow \frac{5mn + 3m - 9n}{+ -13mn - 2m}$$
  

$$= \frac{-8mn + m - 9n}{+ -13mn - 2m}$$

35. 
$$(8a^2b - 6a) - (2a^2b - 4b + 19)$$
  

$$= 8a^2b - 6a - 2a^2b + 4b - 19$$
  

$$= (8a^2b - 2a^2b) - 6a + 4b - 19$$
  

$$= 6a^2b - 6a + 4b - 19$$

36. a.  $x + (x + 1) = (x + x) + 1 = 2x + 1$

b. The sum  $2x + 1$  will always represent an odd number because 2 times any number is even, and when 1 is added the number becomes odd.

### Problem Solving

37. 
$$C = -0.0182t^3 + 0.522t^2 - 2.59t + 47$$
  

$$+ -B = 0.0262t^3 - 0.376t^2 + 0.574t - 9.67$$
  

$$C - B = 0.0080t^3 + 0.146t^2 - 2.016t + 37.33$$

For 2002, let  $t = 10$

$$C - B = 0.008(10)^3 + 0.146(10)^2 - 2.016(10) + 37.33$$
  

$$= 39.77$$

About 39,770,000 more people camped than backpacked in 2002.

38. 
$$I = -137.63t^2 + 2705.2t + 15,111$$
  

$$+ -D = -442.14t - 14,433$$
  

$$I - D = -137.63t^2 + 2263.06t + 678$$

For 2002, let  $t = 12$

$$I - D = -137.63(12)^2 + 2263.06(12) + 678$$
  

$$= 8016$$

The difference in average costs for a new imported car and a new domestic car in 2002 was about \$8016.

39. a.  $T = A + J$   

$$= (9.5t^3 - 58t^2 + 66t + 500) + (-15t^2 + 64t + 360)$$
  

$$= 9.5t^3 + (-58t^2 - 15t^2) + (66t + 64t) + (500 + 360)$$
  

$$= 9.5t^3 - 73t^2 + 130t + 860$$

b. For 2002, let  $t = 4$ :

$$T = 9.5(4)^3 - 73(4)^2 + 130(4) + 860 = 820$$

For 1998, let  $t = 0$ :

$$T = 9.5(0)^3 - 73(0)^2 + 130(0) + 860 = 860$$

860 million books were sold in 1998, while 820 million books were sold in 2002. So, more books were sold in 1998.

40.  $T = B + R$   

$$= (-18.53t^2 + 975.8t + 48,140) + (80.8t + 8049)$$
  

$$= -18.53t^2 + 1056.6t + 56,189$$

For 2012, let  $t = 27$ :

$$B = -18.53(27)^2 + 975.8(27) + 48,140 \approx 60,978$$

$$T = -18.53(27)^2 + 1056.6(27) + 56,189 \approx 71,209$$

$$\frac{B}{T} = \frac{60,978}{71,209} \approx 0.856$$

About 85.6% of students are expected to enroll in public schools in 2012.

41. a.  $D = W + L = (-0.44t^2 + 34t + 4.7) + (15t + 15)$   

$$= -0.44t^2 + 49t + 19.7$$

# Chapter 9 *continued*

b. Let  $t = 21$ :

$$D = -0.44(21)^2 + 49(21) + 19.7 = 855$$

Cy Young had about 855 decisions during his career.

c. Let  $t = 21$ :

$$W = -0.44(21)^2 + 34(21) + 4.7 = 525$$

Cy Young had about 525 wins during his career.

$$P = \frac{\text{wins}}{\text{decisions}} = \frac{525}{855} \approx 0.61$$

By finding his total wins and dividing it by his total decisions, you can conclude that about 61% of his decisions were wins.

42. a. Let  $t$  represent the number of years since 1970,  $P$  represent the total U.S. energy production (in quadrillion BTU), and the  $C$  represent the total U.S. energy consumption (in quadrillion BTU).

$$\begin{array}{rclcl} \text{Total} & = & \text{Initial} & + & \text{Rate of} & \cdot & \text{Number of} \\ \text{amount} & & \text{amount} & & \text{increase} & & \text{years} \end{array}$$

$$P = 63.5 + 0.2813 \cdot t$$

$$C = 67.86 + 0.912 \cdot t$$

Two equations for total energy production and consumption are  $P = 0.2813t + 63.5$  and  $C = 0.912t + 67.86$ .

- b.  $C - P = 0.912t + 67.86 - (0.2813t + 63.5)$   
 $= (0.912t - 0.2813t) + (67.86 - 63.5)$   
 $= 0.6307t + 4.36$

For 1970, let  $t = 0$

$$C - P = 0.6307(0) + 4.36 = 4.36$$

In 1970, 4.36 quadrillion more BTU of energy was consumed than produced in the U.S.

For 2001, let  $t = 31$ :

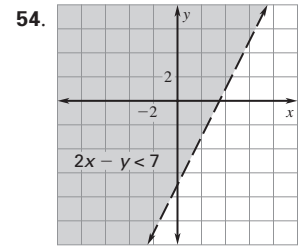
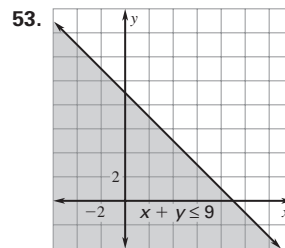
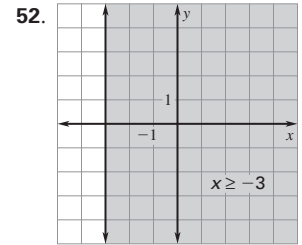
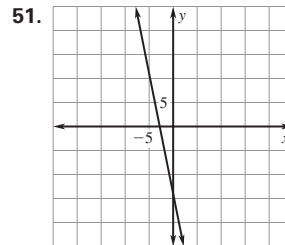
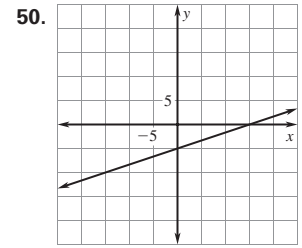
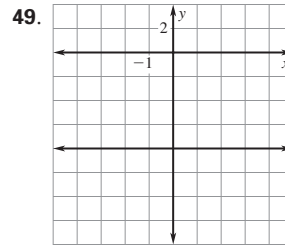
$$C - P = 0.6307(31) + 4.36 \approx 23.91$$

In 2001, about 23.91 quadrillion more BTU of energy was consumed than produced in the U.S.

The change in the amount of energy consumed from 1970 to 2001 was about  $(0.912(31) + 67.86) - (0.912(0) + 67.86) = 28.272$  quadrillion BTU.

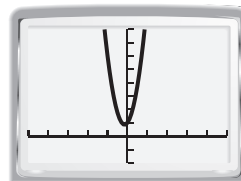
### Mixed Review

43.  $0.6(3 - x) = 0.6(3) - 0.6x = 1.8 - 0.6x$   
 44.  $4(y + 6) = 4y + 4(6) = 4y + 24$   
 45.  $4(1 - b) - 5b = 4 - 4b - 5b = 4 - 9b$   
 46.  $-4(16c - 8) = -4(16c) - 4(-8) = -64c + 32$   
 47.  $(6t^7)^2 = 6^2(t^7)^2 = 36t^{14}$   
 48.  $n(2m^2n) = 2m^2n^{1+1} = 2m^2n^2$



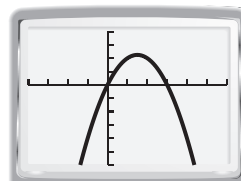
### Graphing Calculator Activity 9.1 (p. 560)

1.  $(6x^2 + 4x - 1) + (x^2 - 2x + 2)$   
 $= (6x^2 + x^2) + (4x - 2x) + (-1 + 2)$   
 $= 7x^2 + 2x + 1$

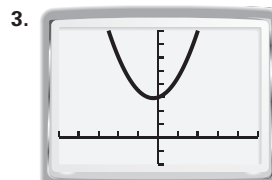


The thick curve coincides with the thin curve, so the sum is correct.

2.  $(3x^2 - 2x + 1) - (4x^2 - 5x + 1)$   
 $= 3x^2 - 2x + 1 - 4x^2 + 5x - 1$   
 $= (3x^2 - 4x^2) + (-2x + 5x) + (1 - 1)$   
 $= -x^2 + 3x$

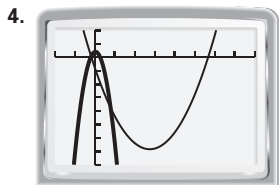


The thick curve coincides with the thin curve, so the difference is correct.



The thick curve coincides with the thin curve, so the sum is correct.

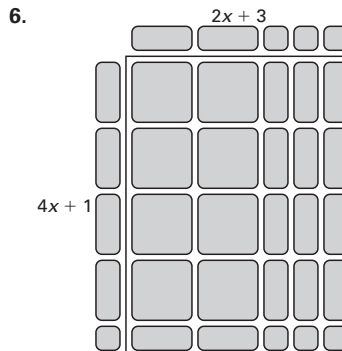
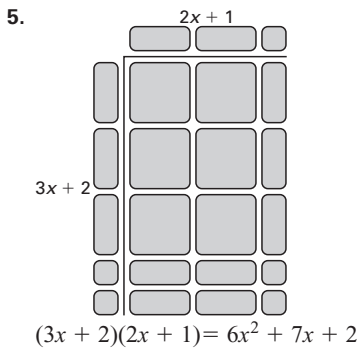
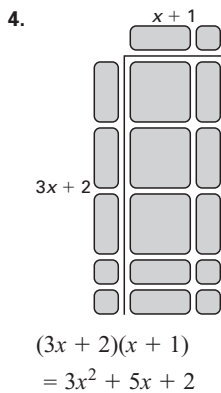
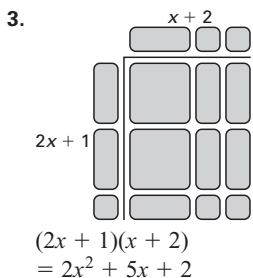
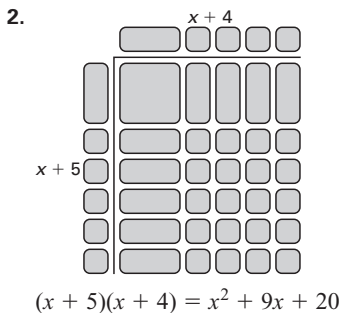
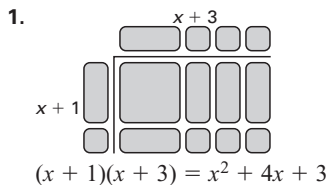
# Chapter 9, continued



The thick curve does not coincide with the thin curve so the difference is incorrect.

The correct answer is  
 $(-4x^2 - 5x - 1) - (-5x^2 + 6x + 3)$   
 $= -4x^2 - 5x - 1 + 5x^2 - 6x - 3 = x^2 - 11x - 4.$

## Investigating Algebra Activity 9.2 (p. 561)



$$(4x + 1)(2x + 3) = 8x^2 + 14x + 3$$

7.  $x(2x + 1) = 2x(x) + x = 2x^2 + x$   
 $3(2x + 1) = 3(2x) + 3(1) = 6x + 3$   
 $2x^2 + x + 6x + 3 = 2x^2 + 7x + 3$

The answer suggests you can find the product  $(x + 3)(2x + 1)$  by multiplying one polynomial by each term of the other polynomial and adding the products.

## Lesson 9.2

### 9.2 Guided Practice (pp. 562–565)

1.  $x(7x^2 + 4) = x(7x^2) + x(4) = 7x^3 + 4x$   
 2.  $(a + 3)(2a + 1) = 2a^2 + a + 6a + 3 = 2a^2 + 7a + 3$

	$2a$	$1$
$a$	$2a^2$	$a$
$3$	$6a$	$3$

3.  $(4n - 1)(n + 5) = [4n + (-1)](n + 5)$

	$n$	$5$
$4n$	$4n^2$	$20n$
$-1$	$-n$	$-5$

$$(4n - 1)(n + 5) = 4n^2 + 20n - n - 5 = 4n^2 + 19n - 5$$

4. 
$$\begin{array}{r} x^2 + 2x + 1 \\ \underline{\phantom{x^2} + x + 2} \\ 2x^2 + 4x + 2 \\ \underline{\phantom{2x^2} + 2x^2 + x} \\ x^3 + 4x^2 + 5x + 2 \end{array}$$

5.  $(3y^2 - y + 5)(2y - 3)$   
 $= 3y^2(2y - 3) - y(2y - 3) + 5(2y - 3)$   
 $= 6y^3 - 9y^2 - 2y^2 + 3y + 10y - 15$   
 $= 6y^3 - 11y^2 + 13y - 15$

6.  $(4b - 5)(b - 2)$   
 $= 4b(b) + 4b(-2) + (-5)(b) + (-5)(-2)$   
 $= 4b^2 + (-8b) + (-5b) + 10$   
 $= 4b^2 - 13b + 10$



## Chapter 9, continued

16. The multiplication was done correctly, but when the sum of the products was found, the exponents were added together instead of just the coefficients.

$$\begin{array}{r} 2x^2 - 3x - 4 \\ \quad \quad \quad x + 7 \\ \hline 14x^2 - 21x - 28 \\ \quad \quad \quad 2x^3 - 3x^2 - 4x \\ \hline 2x^3 + 11x^2 - 25x - 28 \end{array}$$

17.  $(y + 6)(y - 5) = y(y + 6) - 5(y + 6)$   
 $= y^2 + 6y - 5y - 30$   
 $= y^2 + y - 30$
18.  $(5x - 8)(2x - 5) = 2x(5x - 8) - 5(5x - 8)$   
 $= 10x^2 - 16x - 25x + 40$   
 $= 10x^2 - 41x + 40$
19.  $(7w + 5)(11w - 3) = 11w(7w + 5) - 3(7w + 5)$   
 $= 77w^2 + 55w - 21w - 15$   
 $= 77w^2 + 34w - 15$
20.  $(b - 2)(b^2 - b + 1) = b^2(b - 2) - b(b - 2) + 1(b - 2)$   
 $= b^3 - 2b^2 - b^2 + 2b + b - 2$   
 $= b^3 - 3b^2 + 3b - 2$
21.  $(s + 4)(s^2 + 6s - 5) = s^2(s + 4) + 6s(s + 4) - 5(s + 4)$   
 $= s^3 + 4s^2 + 6s^2 + 24s - 5s - 20$   
 $= s^3 + 10s^2 + 19s - 20$
22.  $(-r + 7)(2r^2 - r - 9)$   
 $= 2r^2(-r + 7) - r(-r + 7) - 9(-r + 7)$   
 $= -2r^3 + 14r^2 + r^2 - 7r + 9r - 63$   
 $= -2r^3 + 15r^2 + 2r - 63$
23.  $(5x + 2)(-3x^2 + 4x - 1)$   
 $= -3x^2(5x + 2) + 4x(5x + 2) - 1(5x + 2)$   
 $= -15x^3 - 6x^2 + 20x^2 + 8x - 5x - 2$   
 $= -15x^3 + 14x^2 + 3x - 2$
24.  $y^2 + 8y - 6$       25.  $6z^2 + z - 1$   
 $\quad \quad \quad 4y - 3$        $\quad \quad \quad 9z - 5$   
 $\hline -3y^2 - 24y + 18$        $\hline -30z^2 - 5z + 5$   
 $\quad \quad \quad 4y^3 + 32y^2 - 24y$        $\quad \quad \quad 54z^3 + 9z^2 - 9z$   
 $\hline 4y^3 + 29y^2 - 48y + 18$        $\hline 54z^3 - 21z^2 - 14z + 5$
26. B;  $(2x - 9)(4x + 1) = 2x(4x) + 2x(1) - 9(4x) - 9(1)$   
 $= 8x^2 + 2x - 36x - 9$   
 $= 8x^2 - 34x - 9$
27.  $(2r - 1)(5r + 3) = 2r(5r) + 2r(3) - 1(5r) - 1(3)$   
 $= 10r^2 + 6r - 5r - 3$   
 $= 10r^2 + r - 3$
28.  $(7a - 2)(3a - 4) = 7a(3a) + 7a(-4) - 2(3a) - 2(-4)$   
 $= 21a^2 - 28a - 6a + 8$   
 $= 21a^2 - 34a + 8$
29.  $(4m + 9)(2m + 7) = 4m(2m) + 4m(7) + 9(2m) + 9(7)$   
 $= 8m^2 + 28m + 18m + 63$   
 $= 8m^2 + 46m + 63$

30.  $(8t + 11)(6t - 1) = 8t(6t) + 8t(-1) + 11(6t) + 11(-1)$   
 $= 48t^2 - 8t + 66t - 11$   
 $= 48t^2 + 58t - 11$
31.  $(4x - 5)(12x - 7)$   
 $= 4x(12x) + 4x(-7) - 5(12x) - 5(-7)$   
 $= 48x^2 - 28x - 60x + 35$   
 $= 48x^2 - 88x + 35$
32.  $(8z + 3)(5z + 4) = 8z(5z) + 8z(4) + 3(5z) + 3(4)$   
 $= 40z^2 + 32z + 15z + 12$   
 $= 40z^2 + 47z + 12$
33.  $p(2p - 3) + (p - 3)(p + 3)$   
 $= p(2p) + p(-3) + p(p) + p(3) - 3(p) - 3(3)$   
 $= 2p^2 - 3p + p^2 + 3p - 3p - 9$   
 $= 3p^2 - 3p - 9$
34.  $x^2(7x + 5) - (2x + 6)(x - 1)$   
 $= x^2(7x) + x^2(5) - [2x(x) + 2x(-1) + 6(x) + 6(-1)]$   
 $= 7x^3 + 5x^2 - (2x^2 - 2x + 6x - 6)$   
 $= 7x^3 + 5x^2 - 2x^2 - 4x + 6$   
 $= 7x^3 + 3x^2 - 4x + 6$
35.  $-3c^2(c + 11) - (4c - 5)(3c - 2)$   
 $= -3c^2(c) - 3c^2(11) - [4c(3c) + 4c(-2) - 5(3c) - 5(-2)]$   
 $= -3c^3 - 33c^2 - (12c^2 - 8c - 15c + 10)$   
 $= -3c^3 - 33c^2 - 12c^2 + 23c - 10$   
 $= -3c^3 - 45c^2 + 23c - 10$
36.  $2w^3(2w^3 - 7w - 1) + w(5w^2 + 2w)$   
 $= 2w^3(2w^3) + 2w^3(-7w) + 2w^3(-1) + w(5w^2)$   
 $\quad \quad \quad + w(2w)$   
 $= 4w^6 - 14w^4 - 2w^3 + 5w^3 + 2w^2$   
 $= 4w^6 - 14w^4 + 3w^3 + 2w^2$
37. Area = length • width  
 $= (2x - 9)(x + 5)$   
 $= 2x^2 + 10x - 9x - 45$   
 $= 2x^2 + x - 45$
38. Area = length • width  
 $= (x + 6)(2x)$   
 $= 2x(x) + 2x(6)$   
 $= 2x^2 + 12x$
39. Area = length • width  
 $= (x + 5)(x + 3)$   
 $= x^2 + 3x + 5x + 15$   
 $= x^2 + 8x + 15$

## Chapter 9, continued

$$\begin{aligned}
 40. \text{ Area} &= \text{Area of rectangle} - \text{Area of triangle} \\
 &= \text{length} \cdot \text{width} - \frac{1}{2} \cdot \text{base} \cdot \text{height} \\
 &= (x + 6)(x + 5) - \frac{1}{2}(x + 6)(x + 5) \\
 &= \frac{1}{2}(x + 6)(x + 5) \\
 &= \frac{1}{2}(x^2 + 5x + 6x + 30) \\
 &= \frac{1}{2}(x^2 + 11x + 30) \\
 &= \frac{1}{2}x^2 + \frac{11}{2}x + 15
 \end{aligned}$$

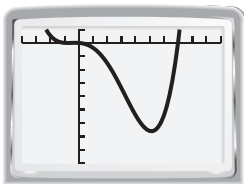
$$\begin{aligned}
 41. \text{ Area} &= \text{Area of outer rectangle} \\
 &\quad - \text{Area of inner rectangle} \\
 &= \text{length} \cdot \text{width} - \text{length} \cdot \text{width} \\
 &= 10 \cdot 8 - 3x \cdot 2x \\
 &= 80 - 6x^2 \\
 &= -6x^2 + 80
 \end{aligned}$$

$$\begin{aligned}
 42. \text{ Area} &= \text{Area of outer rectangle} - \text{Area of inner rectangle} \\
 &= \text{length} \cdot \text{width} - \text{length} \cdot \text{width} \\
 &= (x + 1)(x + 1) - (x - 7)(5) \\
 &= x^2 + x + x + 1 - 5x + 35 \\
 &= x^2 - 3x + 36
 \end{aligned}$$

$$\begin{aligned}
 43. f(x) \cdot g(x) &= (x - 11)(2x + 12) \\
 &= 2x^2 + 12x - 22x - 132 \\
 &= 2x^2 - 10x - 132
 \end{aligned}$$

$$\begin{aligned}
 44. C; \\
 f(x) \cdot g(x) &= -2x^2(x^3 - 5x^2 + 2x - 1) \\
 &= -2x^2(x^3) - 2x^2(-5x^2) - 2x^2(2x) \\
 &\quad - 2x^2(-1) \\
 &= -2x^5 + 10x^4 - 4x^3 + 2x^2
 \end{aligned}$$

$$\begin{aligned}
 45. (x^2 - 7x)(2x^2 + 3x + 1) \\
 &= 2x^2(x^2 - 7x) + 3x(x^2 - 7x) + 1(x^2 - 7x) \\
 &= 2x^4 - 14x^3 + 3x^3 - 21x^2 + x^2 - 7x \\
 &= 2x^4 - 11x^3 - 20x^2 - 7x
 \end{aligned}$$



The thin curve represents  $y = (x^2 - 7x)(2x^2 + 3x + 1)$  and the thick curve represents  $y = 2x^4 - 11x^3 - 20x^2 - 7x$ . Because the graphs coincide, the product is correct.

$$\begin{aligned}
 46. (x - y)(3x + 4y) &= x(3x) + x(4y) - y(3x) - y(4y) \\
 &= 3x^2 + 4xy - 3xy - 4y^2 \\
 &= 3x^2 + xy - 4y^2
 \end{aligned}$$

$$\begin{aligned}
 47. (x^2y + 9y)(2x + 3y) \\
 &= x^2y(2x) + x^2y(3y) + 9y(2x) + 9y(3y) \\
 &= 2x^3y + 3x^2y^2 + 18xy + 27y^2
 \end{aligned}$$

$$\begin{aligned}
 48. (x^2 - 5xy + y^2)(4xy) &= x^2(4xy) - 5xy(4xy) + y^2(4xy) \\
 &= 4x^3y - 20x^2y^2 + 4xy^3
 \end{aligned}$$

### Problem Solving

$$\begin{aligned}
 49. \text{ a. Area} &= \text{length} \cdot \text{width} \\
 &= (2x + 20)(2x + 22) \\
 &= 4x^2 + 44x + 40x + 440 \\
 &= 4x^2 + 84x + 440
 \end{aligned}$$

$$\text{ b. When } x = 4: \text{ Area} = 4(4)^2 + 84(4) + 440 = 840$$

When the width of the frame is 4 inches, the combined area is 840 square inches.

$$\begin{aligned}
 50. \text{ a. Area} &= \text{length} \cdot \text{width} \\
 &= (x + 40)(2x + 20) \\
 &= 2x^2 + 20x + 80x + 800 \\
 &= 2x^2 + 100x + 800
 \end{aligned}$$

$$\begin{aligned}
 \text{ b. When } x = 5: \text{ Area} &= 2(5)^2 + 100(5) + 800 \\
 &= 50 + 500 + 800 \\
 &= 1350
 \end{aligned}$$

When the walkway is 5 feet wide, the combined area is 1350 square feet.

$$\begin{aligned}
 51. \text{ a. When } t = 0: \\
 R &= -336(0)^2 + 1730(0) + 12,300 = 12,300 \\
 P &= 0.00351(0)^2 - 0.0249(0) + 0.171 = 0.171
 \end{aligned}$$

When  $t = 0$ ,  $R \cdot P$  represents the amount of money (in millions of dollars) that people between the ages 15 and 19 years old spent on sound recordings in the U.S. in 1997.

$$\begin{aligned}
 \text{ b. } T &= R \cdot P \\
 &= \frac{-336t^2 + 1730t + 12,300}{0.00351t^2 - 0.0249t + 0.171} \\
 &\quad \frac{-57.46t^2 + 295.83t + 2103.3}{8.37t^3 - 43.08t^2 - 306.27t} \\
 &\quad \frac{-1.18t^4 + 6.07t^3 + 43.17t^2}{-1.18t^4 + 14.4t^3 - 57.4t^2 - 10.4t + 2103.3}
 \end{aligned}$$

$$\begin{aligned}
 \text{ c. For 2002, let } t = 5: \\
 T &= -1.18(5)^4 + 14.4(5)^3 - 57.4(5)^2 - 10.4(5) \\
 &\quad + 2103.3 = 1678.8
 \end{aligned}$$

In 2002, people between 15 and 19 years old spent about \$1678.8 million on sound recordings in the U.S.

$$\begin{aligned}
 52. \text{ a. } N &= H \cdot P \\
 &= (1570t + 89,000)(0.0013t + 0.094) \\
 &= 1570t(0.0013t) + 1570t(0.094) + 89,000(0.0013t) \\
 &\quad + 89,000(0.094) \\
 &= 2.041t^2 + 147.58t + 115.7t + 8366 \\
 &= 2.041t^2 + 263.28t + 8366
 \end{aligned}$$

The number of vacant houses is found by multiplying the percent of housing units that are vacant by the total number of housing units.

$$\begin{aligned}
 \text{ b. For 2002, let } t = 22: N &= 2.041(22)^2 + 263.28(22) \\
 &\quad + 8366 \approx 15,146
 \end{aligned}$$

About 15,146 housing units were vacant in 2002.



## Chapter 9, continued

5.  $(2y + 5)^2 = (2y)^2 + 2(2y)(5) + 5^2 = 4y^2 + 20y + 25$
6.  $(t - 7)^2 = t^2 - 2(t)(7) + (7)^2 = t^2 - 14t + 49$
7.  $(n - 11)^2 = n^2 - 2(n)(11) + (11)^2 = n^2 - 22n + 121$
8.  $(6b - 1)^2 = (6b)^2 - 2(6b)(1) + (1)^2 = 36b^2 - 12b + 1$
9. The middle term in the trinomial product is missing.  
 $(s - 3)^2 = s^2 - 2(s)(3) + (3)^2 = s^2 - 6s + 9$
10. The second term was not multiplied by 2.  
 $(2d - 10)^2 = 4d^2 - 2(2d)(10) + (10)^2$   
 $= 4d^2 - 40d + 100$
11.  $(t + 4)(t - 4) = t^2 - 4^2 = t^2 - 16$
12.  $(m - 6)(m + 6) = m^2 - 6^2 = m^2 - 36$
13.  $(2x + 1)(2x - 1) = (2x)^2 - 1^2 = 4x^2 - 1$
14.  $(3x - 1)(3x + 1) = (3x)^2 - 1^2 = 9x^2 - 1$
15.  $(7 + w)(7 - w) = 7^2 - w^2 = 49 - w^2$
16.  $(3s - 8)(3s + 8) = (3s)^2 - 8^2 = 9s^2 - 64$
17.  $B$ ;  $(7x + 3)(7x - 3) = (7x)^2 - 3^2 = 49x^2 - 9$
18.  $D$ ;  $(5n - 3)^2 = (5n)^2 - 2(5n)(3) + (3)^2$   
 $= 25n^2 - 30n + 9$
19. *Sample answer:*  $16 \cdot 24$  can be written as the sum and difference pattern  $(20 - 4)(20 + 4)$ .
20. *Sample answer:*  $28 \cdot 32$  can be written as the sum and difference pattern  $(30 - 2)(30 + 2)$ .
21. *Sample answer:*  $17^2$  can be written as the square of a binomial pattern  $(20 - 3)^2$ .
22. *Sample answer:*  $44^2$  can be written as the square of a binomial pattern  $(40 + 4)^2$ .
23.  $(r + 9s)^2 = r^2 + 2(r)(9s) + (9s)^2 = r^2 + 18rs + 81s^2$
24.  $(6x + 5)^2 = (6x)^2 + 2(6x)(5) + 5^2 = 36x^2 + 60x + 25$
25.  $(3m + 11n)(3m - 11n) = (3m)^2 - (11n)^2$   
 $= 9m^2 - 121n^2$
26.  $(7a + 8b)(7a - 8b) = (7a)^2 - (8b)^2 = 49a^2 - 64b^2$
27.  $(3m - 7n)^2 = (3m)^2 - 2(3m)(7n) + (7n)^2$   
 $= 9m^2 - 42mn + 49n^2$
28.  $(13 - 2x)^2 = 13^2 - 2(13)(2x) + (2x)^2$   
 $= 169 - 52x + 4x^2$
29.  $(3f - 9)(3f + 9) = (3f)^2 - 9^2 = 9f^2 - 81$
30.  $(9 - 4t)(9 + 4t) = 9^2 - (4t)^2 = 81 - 16t^2$
31.  $(3x + 8y)^2 = (3x)^2 + 2(3x)(8y) + (8y)^2$   
 $= 9x^2 + 48xy + 64y^2$
32.  $(-x - 2y)^2 = (-x)^2 - 2(-x)(2y) + (2y)^2$   
 $= x^2 + 4xy + 4y^2$
33.  $(2a - 5b)(2a + 5b) = (2a)^2 - (5b)^2 = 4a^2 - 25b^2$
34.  $(6x + y)(6x - y) = (6x)^2 - y^2 = 36x^2 - y^2$
35.  $f(x) \cdot g(x) = (3x + 0.5)(3x - 0.5) = (3x)^2 - (0.5)^2$   
 $= 9x^2 - 0.25$
36.  $(f(x))^2 = (3x + 0.5)^2 = (3x)^2 + 2(3x)(0.5) + (0.5)^2$   
 $= 9x^2 + 3x + 0.25$
37.  $(g(x))^2 = (3x - 0.5)^2 = (3x)^2 - 2(3x)(0.5) + (0.5)^2$

$$= 9x^2 - 3x + 0.25$$

38.  $x + 11$  and  $x - 11$ ; using the sum and difference pattern,  
 $(x + 11)(x - 11) = x^2 - 121$ .
39.  $(a + b)^3 = (a + b)(a + b)^2 = (a + b)(a^2 + 2ab + b^2)$   
 $= a^2(a + b) + 2ab(a + b) + b^2(a + b)$   
 $= a^3 + a^2b + 2a^2b + 2ab^2 + ab^2 + b^3$   
 $= a^3 + 3a^2b + 3ab^2 + b^3$

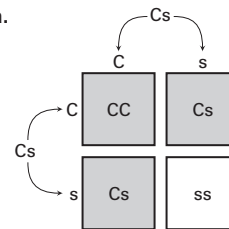
### Problem Solving

40. a. In the Punnett square, 1 of the 4 possible gene combinations results in a yellow pod. So, 25% of the possible gene combinations result in a yellow pod.

b.  $(0.5G + 0.5y)^2 = (0.5G)^2 + 2(0.5G)(0.5y) + (0.5y)^2$   
 $= 0.25G^2 + 0.5Gy + 0.25y^2$

$\uparrow$                        $\uparrow$                        $\uparrow$   
 25% GG            50% Gy            25% yy  
 green pod        green pod        yellow pod

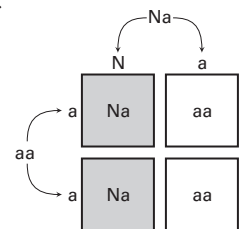
41. a.



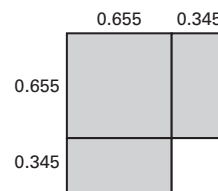
b.  $(0.5C + 0.5s)^2 = (0.5C)^2 + 2(0.5C)(0.5s) + (0.5s)^2$   
 $= 0.25C^2 + 0.5Cs + 0.25s^2$

- c. 25% + 50% = 75% of the possible gene combinations will result in a curved thumb.

42. 50%; In the Punnett square, half of the possible combinations are  $aa$ , which result in an albino python.



43. a. Find the sum of the areas of the regions that contain at least one complete pass.



Area =  $(0.655)^2 + (0.655)(0.345) + (0.345)(0.655)$   
 $= 0.880975$

About 88.1% of the possible outcomes result in at least one complete pass.



## Chapter 9, continued

### 9.4 Guided Practice (pp. 575–577)

$$1. \quad (x - 5)(x - 1) = 0$$

$$x - 5 = 0 \quad \text{or} \quad x - 1 = 0$$

$$x = 5 \quad \text{or} \quad x = 1$$

The solutions are 5 and 1.

Check:

$$(5 - 5)(5 - 1) \stackrel{?}{=} 0 \qquad (1 - 5)(1 - 1) \stackrel{?}{=} 0$$

$$0 \cdot 4 \stackrel{?}{=} 0 \qquad -4 \cdot 0 \stackrel{?}{=} 0$$

$$0 = 0 \checkmark \qquad 0 = 0 \checkmark$$

$$2. \quad 14m + 35n = 7(2m + 5n)$$

$$3. \quad a^2 + 5a = 0$$

$$a(a + 5) = 0$$

$$a = 0 \text{ or } a + 5 = 0$$

$$a = -5$$

The solutions are 0 and  $-5$ .

$$4. \quad 3s^2 - 9s = 0$$

$$3s(s - 3) = 0$$

$$3s = 0 \quad \text{or} \quad s - 3 = 0$$

$$s = 0 \quad \text{or} \quad s = 3$$

The solutions are 0 and 3.

$$5. \quad 4x^2 - 2x = 0$$

$$2x(2x - 1) = 0$$

$$2x = 0 \quad \text{or} \quad 2x - 1 = 0$$

$$x = 0 \quad \text{or} \quad x = \frac{1}{2}$$

The solutions are 0 and  $\frac{1}{2}$ .

$$6. \quad h = -16t^2 + vt + s$$

$$h = -16t^2 + 12t + 0$$

$$h = -16t^2 + 12t$$

$$0 = -16t^2 + 12t$$

$$0 = 4t(-4t + 3)$$

$$4t = 0 \quad \text{or} \quad -4t + 3 = 0$$

$$t = 0 \quad \text{or} \quad t = \frac{3}{4}$$

The armadillo lands on the ground  $\frac{3}{4}$  of a second after it jumps.

### 9.4 Exercises (pp. 578–580)

#### Skill Practice

1. The vertical motion model is used to describe the height of a projectile. The height (in feet) is  $h = -16t^2 + vt + s$  where  $t$  represents the time (in seconds),  $v$  represents the initial velocity (in feet per second), and  $s$  represents the initial height (in feet).

2. Set  $3x$  and  $x - 7$  equal to zero and solve each equation for  $x$ .

$$3. \quad (x - 5)(x + 3) = 0$$

$$x - 5 = 0 \quad \text{or} \quad x + 3 = 0$$

$$x = 5 \quad \text{or} \quad x = -3$$

The solutions are 5 and  $-3$ .

$$4. \quad (y + 9)(y - 1) = 0$$

$$y + 9 = 0 \quad \text{or} \quad y - 1 = 0$$

$$y = -9 \quad \text{or} \quad y = 1$$

The solutions are  $-9$  and 1.

$$5. \quad (z - 13)(z - 14) = 0$$

$$z - 13 = 0 \quad \text{or} \quad z - 14 = 0$$

$$z = 13 \quad \text{or} \quad z = 14$$

The solutions are 13 and 14.

$$6. \quad (c + 6)(c + 8) = 0$$

$$c + 6 = 0 \quad \text{or} \quad c + 8 = 0$$

$$c = -6 \quad \text{or} \quad c = -8$$

The solutions are  $-6$  and  $-8$ .

$$7. \quad (d - 7)\left(d + \frac{4}{3}\right) = 0$$

$$d - 7 = 0 \quad \text{or} \quad d + \frac{4}{3} = 0$$

$$d = 7 \quad \text{or} \quad d = -\frac{4}{3}$$

The solutions are 7 and  $-\frac{4}{3}$ .

$$8. \quad \left(g - \frac{1}{8}\right)(g + 18) = 0$$

$$g - \frac{1}{8} = 0 \quad \text{or} \quad g + 18 = 0$$

$$g = \frac{1}{8} \quad \text{or} \quad g = -18$$

The solutions are  $\frac{1}{8}$  and  $-18$ .

$$9. \quad (m - 3)(4m + 12) = 0$$

$$m - 3 = 0 \quad \text{or} \quad 4m + 12 = 0$$

$$m = 3 \quad \text{or} \quad m = -3$$

The solutions are 3 and  $-3$ .

$$10. \quad (2n - 14)(3n + 9) = 0$$

$$2n - 14 = 0 \quad \text{or} \quad 3n + 9 = 0$$

$$2n = 14 \quad \text{or} \quad 3n = -9$$

$$n = 7 \quad \text{or} \quad n = -3$$

The solutions are 7 and  $-3$ .

$$11. \quad (3n + 11)(n + 1) = 0$$

$$3n + 11 = 0 \quad \text{or} \quad n + 1 = 0$$

$$n = -\frac{11}{3} \quad \text{or} \quad n = -1$$

The solutions are  $-\frac{11}{3}$  and  $-1$ .

$$12. \quad (3x + 1)(x + 6) = 0$$

$$3x + 1 = 0 \quad \text{or} \quad x + 6 = 0$$

$$x = -\frac{1}{3} \quad \text{or} \quad x = -6$$

The solutions are  $-\frac{1}{3}$  and  $-6$ .

## Chapter 9, continued

- 13.**  $(2y + 5)(7y - 5) = 0$   
 $2y + 5 = 0$  or  $7y - 5 = 0$   
 $2y = -5$  or  $7y = 5$   
 $y = -\frac{5}{2}$  or  $y = \frac{5}{7}$   
 The solutions are  $-\frac{5}{2}$  and  $\frac{5}{7}$ .
- 14.**  $(8z - 6)(12z + 14) = 0$   
 $8z - 6 = 0$  or  $12z + 14 = 0$   
 $8z = 6$  or  $12z = -14$   
 $z = \frac{3}{4}$  or  $z = -\frac{7}{6}$   
 The solutions are  $\frac{3}{4}$  and  $-\frac{7}{6}$ .
- 15.** C;  $(y - 12)(y + 6) = 0$   
 $y - 12 = 0$  or  $y + 6 = 0$   
 $y = 12$  or  $y = -6$   
 The solutions are 12 and  $-6$ .
- 16.** The step of setting each factor to zero was left out.  
 $z - 15 = 0$  or  $z + 21 = 0$   
 $z = 15$  or  $z = -21$
- 17.**  $2x + 2y = 2(x + y)$
- 18.**  $6x^2 - 15y = 3(2x^2 - 5y)$
- 19.**  $3s^4 + 16s = s(3s^3 + 16)$
- 20.**  $5d^6 + 2d^5 = d^5(5d + 2)$
- 21.**  $7w^5 - 35w^2 = 7w^2(w^3 - 5)$
- 22.**  $9m^7 - 3m^2 = 3m^2(3m^5 - 1)$
- 23.**  $15n^3 + 25n = 5n(3n^2 + 5)$
- 24.**  $12a^5 + 8a = 4a(3a^4 + 2)$
- 25.**  $\frac{5}{2}x^6 - \frac{1}{2}x^4 = \frac{1}{2}x^4(5x^2 - 1)$
- 26.** The GCF is  $3x^3$ , not  $3x$ .  
 $18x^8 - 9x^4 - 6x^3 = 3x^3(6x^5 - 3x - 2)$
- 27.**  $b^2 + 6b = 0$   
 $b(b + 6) = 0$   
 $b = 0$  or  $b + 6 = 0$   
 $b = -6$   
 The solutions are 0 and  $-6$ .
- 28.**  $5w^2 - 5w = 0$   
 $5w(w - 1) = 0$   
 $5w = 0$  or  $w - 1 = 0$   
 $w = 0$  or  $w = 1$   
 The solutions are 0 and 1.
- 29.**  $-10n^2 + 35n = 0$   
 $5n(-2n + 7) = 0$   
 $5n = 0$  or  $-2n + 7 = 0$   
 $n = 0$  or  $n = \frac{7}{2}$   
 The solutions are 0 and  $\frac{7}{2}$ .
- 30.**  $2x^2 + 15x = 0$   
 $x(2x + 15) = 0$   
 $x = 0$  or  $2x + 15 = 0$   
 $x = -\frac{15}{2}$   
 The solutions are 0 and  $-\frac{15}{2}$ .
- 31.**  $18c^2 + 6c = 0$   
 $6c(3c + 1) = 0$   
 $6c = 0$  or  $3c + 1 = 0$   
 $c = 0$  or  $c = -\frac{1}{3}$   
 The solutions are 0 and  $-\frac{1}{3}$ .
- 32.**  $-32y^2 - 24y = 0$   
 $-8y(4y + 3) = 0$   
 $-8y = 0$  or  $4y + 3 = 0$   
 $y = 0$  or  $y = -\frac{3}{4}$   
 The solutions are 0 and  $-\frac{3}{4}$ .
- 33.**  $3k^2 = 6k$   
 $3k^2 - 6k = 0$   
 $3k(k - 2) = 0$   
 $3k = 0$  or  $k - 2 = 0$   
 $k = 0$  or  $k = 2$   
 The solutions are 0 and 2.
- 34.**  $6h^2 = 3h$   
 $6h^2 - 3h = 0$   
 $3h(2h - 1) = 0$   
 $3h = 0$  or  $2h - 1 = 0$   
 $h = 0$  or  $h = \frac{1}{2}$   
 The solutions are 0 and  $\frac{1}{2}$ .
- 35.**  $4s^2 = 10s$   
 $4s^2 - 10s = 0$   
 $2s(2s - 5) = 0$   
 $2s = 0$  or  $2s - 5 = 0$   
 $s = 0$  or  $s = \frac{5}{2}$   
 The solutions are 0 and  $\frac{5}{2}$ .
- 36.**  $-42z^2 = 14z$   
 $-42z^2 - 14z = 0$   
 $-14z(3z + 1) = 0$   
 $14z = 0$  or  $3z + 1 = 0$   
 $z = 0$  or  $z = -\frac{1}{3}$   
 The solutions are 0 and  $-\frac{1}{3}$ .
- 37.**  $28m^2 = -8m$   
 $28m^2 + 8m = 0$   
 $4m(7m + 2) = 0$   
 $4m = 0$  or  $7m + 2 = 0$   
 $m = 0$  or  $m = -\frac{2}{7}$   
 The solutions are 0 and  $-\frac{2}{7}$ .
- 38.**  $-12p^2 = -30p$   
 $-12p^2 + 30p = 0$   
 $6p(-2p + 5) = 0$   
 $6p = 0$  or  $-2p + 5 = 0$   
 $p = 0$  or  $p = \frac{5}{2}$   
 The solutions are 0 and  $\frac{5}{2}$ .
- 39.** C;  $4x^2 = x$   
 $4x^2 - x = 0$   
 $x(4x - 1) = 0$   
 $x = 0$  or  $4x - 1 = 0$   
 $x = \frac{1}{4}$   
 The solutions are 0 and  $\frac{1}{4}$ .
- 40.**  $20x^2y^2 - 4xy = 4xy(5xy - 1)$
- 41.**  $8a^2b - 6ab^2 = 2ab(4a - 3b)$
- 42.**  $18s^2t^5 - 2s^3t = 2s^2t(9t^4 - s)$
- 43.**  $v^3 - 5v^2 + 9v = v(v^2 - 5v + 9)$
- 44.**  $-2g^4 + 14g^2 + 6g = -2g(g^3 - 7g - 3)$
- 45.**  $6q^5 - 21q^4 - 15q^2 = 3q^2(2q^3 - 7q^2 - 5)$
- 46.**  $f(x) = x^2 - 15x$   
 $0 = x^2 - 15x$   
 $0 = x(x - 15)$   
 $x = 0$  or  $x - 15 = 0$   
 $x = 15$   
 The zeros are 0 and 15.

## Chapter 9, continued

$$47. f(x) = -2x^2 + x$$

$$0 = -2x^2 + x$$

$$0 = x(-2x + 1)$$

$$x = 0 \text{ or } -2x + 1 = 0$$

$$x = \frac{1}{2}$$

The zeros are 0 and  $\frac{1}{2}$ .

$$48. f(x) = 3x^2 - 27x$$

$$0 = 3x^2 - 27x$$

$$0 = 3x(x - 9)$$

$$3x = 0 \text{ or } x - 9 = 0$$

$$x = 0 \text{ or } x = 9$$

The zeros are 0 and 9.

$$49. ab = 0 \text{ or } ab = 0$$

$$b = \frac{0}{a} \quad a = \frac{0}{b}$$

$$b = 0 \quad a = 0$$

Either  $a = 0$  or  $b = 0$ .

$$50. z = x^2 - xy$$

$$0 = x^2 - xy$$

$$0 = x(x - y)$$

$$x = 0 \text{ or } x - y = 0$$

$$x = y$$

Either  $x = 0$  and  $y =$  any real number, or  $x$  and  $y$  are any real numbers where  $x = y$ .

$$51. \text{ Let } v = 11 \text{ and } s = 0.$$

$$h = -16t^2 + vt + s$$

$$0 = -16t^2 + 11t$$

$$0 = t(-16t + 11)$$

$$t = 0 \text{ or } -16t + 11 = 0$$

$$t = \frac{11}{16}$$

The cat lands on the ground  $\frac{11}{16}$  of a second after it jumps.

$$52. \text{ a. Let } v = 10 \text{ and } s = 0.$$

$$h = -16t^2 + vt + s$$

$$h = -16t^2 + 10t$$

**b.** When  $t = 0.3125$

$$h = -16(0.3125)^2 + 10(0.3125)$$

$$= -1.5625 + 3.125$$

$$= 1.5625$$

The spittle bug can jump 1.5625 feet.

$$53. h = -16t^2 + 4.5t$$

$$0 = -16t^2 + 4.5t$$

$$0 = t(-16t + 4.5)$$

$$t = 0 \text{ or } -16t + 4.5 = 0$$

$$-16t = -4.5$$

$$t = 0.28125$$

The zeros are 0 and 0.28125. These are the times (in seconds) when the penguin leaves the water and reenters the water.

$$54. \text{ Let } v = 3.6 \text{ and } s = 0.$$

$$h = -4.9t^2 + vt + s$$

$$h = -4.9t^2 + 3.6t$$

$$0 = -4.9t^2 + 3.6t$$

$$0 = t(-4.9t + 3.6)$$

$$t = 0 \text{ or } -4.9t + 3.6 = 0$$

$$t \approx 0.73$$

The ball lands after about 0.73 second.

$$55. \text{ a. Let } v = 4.9 \text{ and } s = 0.$$

$$h = -4.9t^2 + vt + s$$

$$h = -4.9t^2 + 4.9t$$

**b.** The rabbit lands when  $h = 0$ .

$$0 = -4.9t^2 + 4.9t$$

$$0 = 4.9t(-t + 1)$$

$$4.9t = 0 \text{ or } -t + 1 = 0$$

$$t = 0 \text{ or } t = 1$$

The rabbit lands 1 second after it leaves the ground, so a reasonable domain is  $0 \leq t \leq 1$ .

$$56. \text{ B; } w(w + 2) = 2w(w - 1)$$

$$w^2 + 2w = 2w^2 - 2w$$

$$-w^2 + 4w = 0$$

$$w(-w + 4) = 0$$

$$w = 0 \text{ or } -w + 4 = 0$$

$$w = 4$$

**57. a.** An equation that relates the areas of the tabletops is

$$w(w + 2) = w(10 - w).$$

**b.**

$$w(w + 2) = w(10 - w)$$

$$w^2 + 2w = 10w - w^2$$

$$2w^2 - 8w = 0$$

$$2w(w - 4) = 0$$

$$2w = 0 \text{ or } w - 4 = 0$$

$$w = 0 \text{ or } w = 4$$

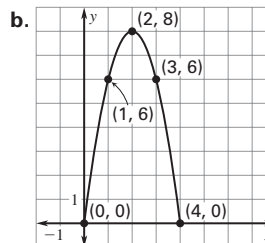
The value of  $w$  is 4 feet.

**c.** Area =  $2[w(2 + w)] = 2(4)(2 + 4) = 48$

The combined area of the tabletops is 48 square feet.

**58. a.**

<b>x</b>	0	1	2	3	4
<b>y</b>	0	6	8	6	0



**c.** The distance between the zeros is 4, so the base is 4 feet wide.

# Chapter 9, continued

59. a.  $y = -0.5x(x - 8)$

$$0 = -0.5x(x - 8)$$

$$-0.5x = 0 \quad \text{or} \quad x - 8 = 0$$

$$x = 0 \quad \text{or} \quad x = 8$$

The distance between the zeros is 8, so the base is 8 feet wide.

- b. The highest point occurs above the center of the base, at  $x = 4$ :

$$y = -0.5(4)(4 - 8)$$

$$y = 8$$

The highest point is 8 feet above the floor.

## Mixed Review

60.  $45(-x)(-x) = 45x^2$

61.  $-9a(-6a)(-a) = -54a^3$

62.  $-7(8n)(-4) = 224n$

63.  $(y - 1)(y + 7) = y^2 + 7y - y - 7$   
 $= y^2 + 6y - 7$

64.  $(m - 5)(m - 13) = m^2 - 13m - 5m + 65$   
 $= m^2 - 18m + 65$

65.  $(2b + 5)(b + 3) = 2b^2 + 6b + 5b + 15$   
 $= 2b^2 + 11b + 15$

66.  $(3p + 8)(4p - 1) = 12p^2 - 3p + 32p - 8$   
 $= 12p^2 + 29p - 8$

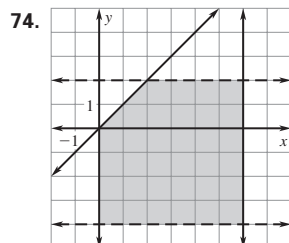
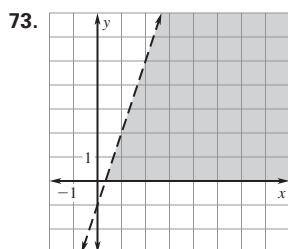
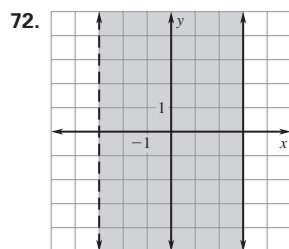
67.  $(5z - 2)(5z - 4) = 25z^2 - 20z - 10z + 8$   
 $= 25z^2 - 30z + 8$

68.  $(9t + 7)(4t + 5) = 36t^2 + 45t + 28t + 35$   
 $= 36t^2 + 73t + 35$

69.  $(2c + 7)^2 = (2c)^2 + 2(2c)(7) + 7^2$   
 $= 4c^2 + 28c + 49$

70.  $(9 - 5w)^2 = 9^2 - 2(9)(5w) + (5w)^2$   
 $= 81 - 90w + 25w^2$

71.  $(3g - 4h)^2 = (3g)^2 - 2(3g)(4h) + (4h)^2$   
 $= 9g^2 - 24gh + 16h^2$



## Mixed Review of Problem Solving (p. 581)

1. a.  $A = \text{length} \cdot \text{width}$

$$= (2x + 72)(2x + 48)$$

$$= 4x^2 + 96x + 144x + 3456$$

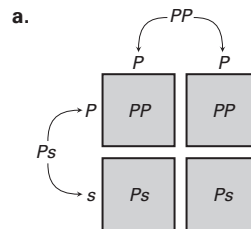
$$= 4x^2 + 240x + 3456$$

- b. When  $x = 4$ :

$$A = 4(4)^2 + 240(4) + 3456 = 4480$$

When the fringe is 4 inches, the total area of the blanket with fringe is 4480 square inches.

2. Sample answer:



- b. Four of the four possible gene combinations, or 100%, result in pinto coloring.

c.  $\left(\frac{1}{2}P + \frac{1}{2}s\right)\left(\frac{1}{2}P + \frac{1}{2}P\right) = \left(\frac{1}{2}P + \frac{1}{2}s\right)P$   
 $= \frac{1}{2}P^2 + \frac{1}{2}Ps$

Because any gene combination with a  $P$  results in pinto coloring, both terms represent pinto offspring.

The sum of the coefficients,  $\frac{1}{2} + \frac{1}{2} = 1$ , shows that 100% of the offspring will be pinto.

3. a. The football with the initial vertical velocity of  $\frac{44 \text{ ft}}{\text{sec}}$  is in the air for more time.

- b. When  $v = 44$ :

$$h = -16t^2 + 44t$$

$$0 = -16t^2 + 44t$$

$$0 = 4t(-4t + 11)$$

$$4t = 0 \quad \text{or} \quad 4t + 11 = 0$$

$$t = \frac{11}{4} = 2.75 \text{ seconds}$$

- When  $v = 40$ :

$$h = -16t^2 + 40t$$

$$0 = -16t^2 + 40t$$

$$0 = 8t(-2t + 5)$$

$$8t = 0 \quad \text{or} \quad -2t + 5 = 0$$

$$t = \frac{5}{2} = 2.5 \text{ seconds}$$

The first football stays in the air  $2.75 - 2.5 = 0.25$  second longer than the second football.

4. The highest power in the polynomial is 3, so the polynomial is of degree 3.

5. a.  $T = C + S$

$$= 0.067t^3 - 0.107t^2 + 0.27t + 3.5 + 0.416t + 1.24$$

$$= 0.067t^3 - 0.107t^2 + 0.686t + 4.74$$

- b. For 1992, let  $t = 0$ :

$$T = 0.067(0)^3 - 0.107(0)^2 + 0.686(0) + 4.74 = 4.74$$

- For 2000, let  $t = 8$ :

$$T = 0.067(8)^3 - 0.107(8)^2 + 0.686(8) + 4.74$$

$$= 37.684$$

## Chapter 9, continued

The total participation in these activities was 4.74 million in 1992 and about 37.684 million in 2000.

$$\begin{aligned} \text{c. Average rate of change} &= \frac{\text{change in participants}}{\text{change in time}} \\ &= \frac{37.684 \text{ million} - 4.74 \text{ million}}{8 - 0} \\ &= 4.118 \end{aligned}$$

The average rate of change was about 4.118 million people each year.

$$\begin{aligned} \text{6. a. } A &= \pi R^2 \\ &= \pi (r + 2)^2 \\ &= \pi (r^2 + 4r + 4) \\ &= \pi r^2 + 4\pi r + 4\pi \end{aligned}$$

$$\text{b. When } 2r = 3, r = \frac{3}{2}:$$

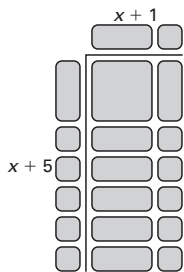
$$A = \pi \left(\frac{3}{2} + 2\right)^2 = \pi \left(\frac{7}{2}\right)^2 = \frac{49}{4}\pi = 12.25\pi$$

The area of the rug is  $12.25\pi$  square feet. Because the diameter of the inner circle is 3 feet, its radius is  $\frac{3}{2}$  feet, and you can substitute this for  $r$  in the equation for area.

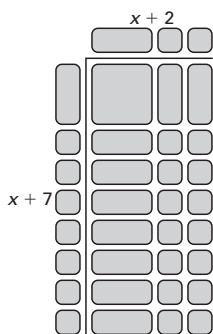
### Investigating Algebra Activity 9.5 (p. 582)

$$\begin{aligned} \text{1. } (x + 4)(x + 2) &= x^2 + 2x + 4x + 8 \\ &= x^2 + 6x + 8 \checkmark \end{aligned}$$

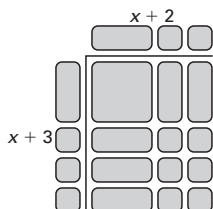
$$\text{2. } \begin{array}{l} \text{The side lengths of the rectangle} \\ \text{represent the polynomials } x + 5 \\ \text{and } x + 1. \text{ So, } x^2 + 6x + 5 = \\ (x + 1)(x + 5). \end{array}$$



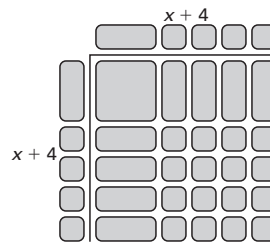
$$\text{3. } \begin{array}{l} \text{The side lengths of the rectangle} \\ \text{represent the polynomials } x + 7 \\ \text{and } x + 2. \text{ So, } x^2 + 9x + 14 = \\ (x + 7)(x + 2). \end{array}$$



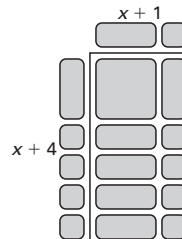
$$\text{4. } \begin{array}{l} \text{The side lengths of the rectangle} \\ \text{represent the polynomials } x + 2 \\ \text{and } x + 3. \text{ So, } x^2 + 2x + 6 = \\ (x + 2)(x + 3). \end{array}$$



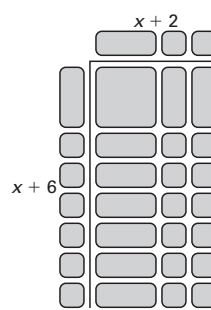
$$\text{5. } \begin{array}{l} \text{The side lengths of the rectangle} \\ \text{represent the polynomials } x + 4 \\ \text{and } x + 4. \text{ So, } x^2 + 8x + 16 = \\ (x + 4)(x + 4). \end{array}$$



$$\text{6. } \begin{array}{l} \text{The side lengths of the rectangle} \\ \text{represent the polynomials } x + 4 \\ \text{and } x + 1. \text{ So, } x^2 + 5x + 4 = \\ (x + 1)(x + 4). \end{array}$$



$$\text{7. } \begin{array}{l} \text{The side lengths of the rectangle} \\ \text{represent the polynomials } x + 6 \\ \text{and } x + 2. \text{ So, } x^2 + 8x + 12 = \\ (x + 6)(x + 2). \end{array}$$



$$\begin{aligned} \text{8. } p + q &= 6 \\ p \cdot q &= 8 \end{aligned}$$

### 9.5 Guided Practice (pp. 583–585)

Factors of 2	Sum of factors	
2, 1	$2 + 1 = 3$	correct sum

The factors 2 and 1 have a sum of 3, so they are the correct factors.

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

$$\begin{aligned} \text{Check: } (x + 2)(x + 1) &= x^2 + x + 2x + 2 \\ &= x^2 + 3x + 2 \checkmark \end{aligned}$$

Factors of 10	Sum of factors	
10, 1	$10 + 1 = 11$	$\times$
5, 2	$5 + 2 = 7$	correct sum

The factors 5 and 2 have a sum of 7, so they are the correct factors.

$$a^2 + 7a + 10 = (a + 5)(a + 2)$$

$$\begin{aligned} \text{Check: } (a + 5)(a + 2) &= a^2 + 2a + 5a + 10 \\ &= a^2 + 7a + 10 \checkmark \end{aligned}$$

# Chapter 9, continued

3.

Factors of 14	Sum of factors	
14, 1	$14 + 1 = 15$	✗
7, 2	$7 + 2 = 9$	correct sum

The factors 7 and 2 have a sum of 9, so they are the correct factors.

$$t^2 + 9t + 14 = (t + 7)(t + 2)$$

$$\begin{aligned} \text{Check: } (t + 7)(t + 2) &= t^2 + 2t + 7t + 14 \\ &= t^2 + 9t + 14 \checkmark \end{aligned}$$

4.

Factors of 3	Sum of factors	
-3, -1	$-3 + (-1) = -4$	correct sum

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

5.

Factors of 12	Sum of factors	
-12, -1	$-12 + (-1) = -13$	✗
-6, -2	$-6 + (-2) = -8$	correct sum
-4, -3	$-4 + (-3) = -7$	✗

$$t^2 - 8t + 12 = (t - 6)(t - 2)$$

6.

Factors of -20	Sum of factors	
-20, 1	$-20 + 1 = -19$	✗
20, -1	$20 + (-1) = 19$	✗
-10, 2	$-10 + 2 = -8$	✗
10, -2	$10 + (-2) = 8$	✗
-5, 4	$-5 + 4 = -1$	✗
5, -4	$5 + (-4) = 1$	correct sum

$$m^2 + m - 20 = (m + 5)(m - 4)$$

7.

Factors of -16	Sum of factors	
-16, 1	$-16 + 1 = -15$	✗
16, -1	$16 + (-1) = 15$	✗
-8, 2	$-8 + 2 = -6$	✗
8, -2	$8 + (-2) = 6$	correct sum
-4, 4	$-4 + 4 = 0$	✗

$$w^2 + 6w - 16 = (w + 8)(w - 2)$$

8.

$$\begin{aligned} s^2 - 2s &= 24 \\ s^2 - 2s - 24 &= 0 \\ (s - 6)(s + 4) &= 0 \\ s - 6 = 0 &\text{ or } s + 4 = 0 \\ s = 6 &\text{ or } s = -4 \end{aligned}$$

The solutions of the equation are 6 and -4.

9. Area of 2 banners is  $2(10) = 20$  square feet.

$$\begin{aligned} A &= \ell \cdot w \\ 20 &= (4 + w + 4) \cdot w \\ 0 &= w^2 + 8w - 20 \\ 0 &= (w + 10)(w - 2) \\ w + 10 = 0 &\text{ or } w - 2 = 0 \\ w = -10 &\text{ or } w = 2 \end{aligned}$$

The banner cannot have a negative width, so the width is 2 feet.

## 9.5 Exercises (pp. 586–589)

### Skill Practice

- The factors of  $t^2 + 2t + 3$  are  $t + 2$  and  $t + 1$ .
- If  $x^2 - 8x + 12 = (x + p)(x + q)$ ,  $p$  and  $q$  are negative. Because  $p + q = -8$  is negative and  $pq = 12$  is positive,  $p$  and  $q$  must both be negative.
- $x^2 + 4x + 3 = (x + 3)(x + 1)$
- $a^2 + 6a + 8 = (a + 4)(a + 2)$
- $b^2 - 17b + 72 = (b - 9)(b - 8)$
- $s^2 - 10s + 16 = (s - 8)(s - 2)$
- $z^2 + 8z - 48 = (z + 12)(z - 4)$
- $w^2 + 18w + 56 = (w + 14)(w + 4)$
- $y^2 - 7y - 18 = (y - 9)(y + 2)$
- $n^2 - 9n + 14 = (n - 7)(n - 2)$
- $x^2 + 3x - 70 = (x + 10)(x - 7)$
- $f^2 + 4f - 32 = (f + 8)(f - 4)$
- $m^2 - 7m - 120 = (m - 15)(m + 8)$
- $d^2 - 20d + 99 = (d - 11)(d - 9)$
- $p^2 + 20p + 64 = (p + 16)(p + 4)$
- $x^2 + 6x - 72 = (x + 12)(x - 6)$
- $c^2 + 15c + 44 = (c + 11)(c + 4)$
- The product of  $p$  and  $q$  should be -60 not 60.  
 $s^2 - 17s - 60 = (s - 20)(s + 3)$
- Because  $b = -10$  is negative and  $c = 24$  is positive, both  $p$  and  $q$  need to be negative.  $m^2 - 10m + 24 = (m - 6)(m - 4)$
- $x^2 - 10x + 21 = 0$   
 $(x - 7)(x - 3) = 0$   
 $x - 7 = 0$  or  $x - 3 = 0$   
 $x = 7$  or  $x = 3$   
The solutions are 7 and 3.
- $n^2 - 7n - 30 = 0$   
 $(n - 10)(n + 3) = 0$   
 $n - 10 = 0$  or  $n + 3 = 0$   
 $n = 10$  or  $n = -3$   
The solutions are 10 and -3.

## Chapter 9, continued

22.  $w^2 - 15w + 44 = 0$

$$(w - 11)(w - 4) = 0$$

$$w - 11 = 0 \quad \text{or} \quad w - 4 = 0$$

$$w = 11 \quad \text{or} \quad w = 4$$

The solutions are 11 and 4.

23.  $a^2 + 5a = 50$

$$a^2 + 5a - 50 = 0$$

$$(a + 10)(a - 5) = 0$$

$$a + 10 = 0 \quad \text{or} \quad a - 5 = 0$$

$$a = -10 \quad \text{or} \quad a = 5$$

The solutions are -10 and 5.

24.  $r^2 + 2r = 24$

$$r^2 + 2r - 24 = 0$$

$$(r + 6)(r - 4) = 0$$

$$r + 6 = 0 \quad \text{or} \quad r - 4 = 0$$

$$r = -6 \quad \text{or} \quad r = 4$$

The solutions are -6 and 4.

25.  $t^2 + 9t = -20$

$$t^2 + 9t + 20 = 0$$

$$(t + 5)(t + 4) = 0$$

$$t + 5 = 0 \quad \text{or} \quad t + 4 = 0$$

$$t = -5 \quad \text{or} \quad t = -4$$

The solutions are -5 and -4.

26.  $y^2 - 2y - 8 = 7$

$$y^2 - 2y - 15 = 0$$

$$(y - 5)(y + 3) = 0$$

$$y - 5 = 0 \quad \text{or} \quad y + 3 = 0$$

$$y = 5 \quad \text{or} \quad y = -3$$

The solutions are 5 and -3.

27.  $m^2 + 22 = -23m$

$$m^2 + 23m + 22 = 0$$

$$(m + 22)(m + 1) = 0$$

$$m + 22 = 0 \quad \text{or} \quad m + 1 = 0$$

$$m = -22 \quad \text{or} \quad m = -1$$

The solutions are -22 and -1.

28.  $b^2 + 5 = 8b - 10$

$$b^2 - 8b + 15 = 0$$

$$(b - 5)(b - 3) = 0$$

$$b - 5 = 0 \quad \text{or} \quad b - 3 = 0$$

$$b = 5 \quad \text{or} \quad b = 3$$

The solutions are 5 and 3.

29. C;  $x^2 - 8x = 240$

$$x^2 - 8x - 240 = 0$$

$$(x - 20)(x + 12) = 0$$

$$x - 20 = 0 \quad \text{or} \quad x + 12 = 0$$

$$x = 20 \quad \text{or} \quad x = -12$$

The solutions are 20 and -12.

30.  $f(x) = x^2 + 11x + 18$

$$0 = x^2 + 11x + 18$$

$$0 = (x + 9)(x + 2)$$

$$x + 9 = 0 \quad \text{or} \quad x + 2 = 0$$

$$x = -9 \quad \text{or} \quad x = -2$$

The zeros are -9 and -2.

31.  $g(x) = x^2 + 5x + 6$

$$0 = x^2 + 5x + 6$$

$$0 = (x + 3)(x + 2)$$

$$x + 3 = 0 \quad \text{or} \quad x + 2 = 0$$

$$x = -3 \quad \text{or} \quad x = -2$$

The zeros are -3 and -2.

32.  $h(x) = x^2 - 18x + 32$

$$0 = x^2 - 18x + 32$$

$$0 = (x - 16)(x - 2)$$

$$x - 16 = 0 \quad \text{or} \quad x - 2 = 0$$

$$x = 16 \quad \text{or} \quad x = 2$$

The zeros are 16 and 2.

33.  $f(x) = x^2 - 14x + 45$

$$0 = x^2 - 14x + 45$$

$$0 = (x - 9)(x - 5)$$

$$x - 9 = 0 \quad \text{or} \quad x - 5 = 0$$

$$x = 9 \quad \text{or} \quad x = 5$$

The zeros are 9 and 5.

34.  $h(x) = x^2 - 5x - 24$

$$0 = x^2 - 5x - 24$$

$$0 = (x - 8)(x + 3)$$

$$x - 8 = 0 \quad \text{or} \quad x + 3 = 0$$

$$x = 8 \quad \text{or} \quad x = -3$$

The zeros are 8 and -3.

35.  $g(x) = x^2 - 14x - 51$

$$0 = x^2 - 14x - 51$$

$$0 = (x - 17)(x + 3)$$

$$x - 17 = 0 \quad \text{or} \quad x + 3 = 0$$

$$x = 17 \quad \text{or} \quad x = -3$$

The zeros are 17 and -3.

36.  $g(x) = x^2 + 10x - 39$

$$0 = x^2 + 10x - 39$$

$$0 = (x + 13)(x - 3)$$

$$x + 13 = 0 \quad \text{or} \quad x - 3 = 0$$

$$x = -13 \quad \text{or} \quad x = 3$$

The zeros are -13 and 3.

## Chapter 9, continued

37.  $f(x) = -x^2 + 16x - 28$

$$0 = -x^2 + 16x - 28$$

$$0 = x^2 - 16x + 28$$

$$0 = (x - 14)(x - 2)$$

$$x - 14 = 0 \quad \text{or} \quad x - 2 = 0$$

$$x = 14 \quad \text{or} \quad x = 2$$

The zeros are 14 and 2.

38.  $f(x) = -x^2 + 24x + 180$

$$0 = -x^2 + 24x + 180$$

$$0 = x^2 - 24x - 180$$

$$0 = (x - 30)(x + 6)$$

$$x - 30 = 0 \quad \text{or} \quad x + 6 = 0$$

$$x = 30 \quad \text{or} \quad x = -6$$

The zeros are 30 and  $-6$ .

39.  $s(s + 1) = 72$

$$s^2 + s = 72$$

$$s^2 + s - 72 = 0$$

$$(s + 9)(s - 8) = 0$$

$$s + 9 = 0 \quad \text{or} \quad s - 8 = 0$$

$$s = -9 \quad \text{or} \quad s = 8$$

The solutions are  $-9$  and  $8$ .

40.  $x^2 - 10(x - 1) = -11$

$$x^2 - 10x + 10 = -11$$

$$x^2 - 10x + 21 = 0$$

$$(x - 7)(x - 3) = 0$$

$$x - 7 = 0 \quad \text{or} \quad x - 3 = 0$$

$$x = 7 \quad \text{or} \quad x = 3$$

The solutions are  $7$  and  $3$ .

41.  $q(q + 19) = -34$

$$q^2 + 19q = -34$$

$$q^2 + 19q + 34 = 0$$

$$(q + 17)(q + 2) = 0$$

$$q + 17 = 0 \quad \text{or} \quad q + 2 = 0$$

$$q = -17 \quad \text{or} \quad q = -2$$

The solutions are  $-17$  and  $-2$ .

42.  $x = -4$  or  $x = 6$

$$x + 4 = 0 \quad \text{or} \quad x - 6 = 0$$

$$(x + 4)(x - 6) = 0$$

$$x^2 - 6x + 4x - 24 = 0$$

$$x^2 - 2x - 24 = 0$$

You can obtain an equation by working backwards.

Use the solutions to write factors of a polynomial. Then find and simplify the product to obtain a polynomial.

43.  $A = \ell \cdot w$

$$100 = x(x - 15)$$

$$0 = x^2 - 15x - 100$$

$$0 = (x - 20)(x + 5)$$

$$x - 20 = 0 \quad \text{or} \quad x + 5 = 0$$

$$x = 20 \quad \text{or} \quad x = -5$$

The length cannot be negative, so  $x = 20$ .

The dimensions are 20 inches by 5 inches.

44.  $A = \ell \cdot w$

$$34 = (x + 11)(x - 4)$$

$$34 = x^2 - 4x + 11x - 44$$

$$0 = x^2 + 7x - 78$$

$$0 = (x + 13)(x - 6)$$

$$x + 13 = 0 \quad \text{or} \quad x - 6 = 0$$

$$x = -13 \quad \text{or} \quad x = 6$$

The dimensions cannot be negative, so  $x = 6$ .

The dimensions are 17 meters by 2 meters.

45.  $A = \frac{1}{2}b \cdot h$

$$78 = \frac{1}{2}(x + 20)(x)$$

$$0 = \frac{1}{2}x^2 + 10x - 78$$

$$0 = x^2 + 20x - 156$$

$$0 = (x + 26)(x - 6)$$

$$x + 26 = 0 \quad \text{or} \quad x - 6 = 0$$

$$x = -26 \quad \text{or} \quad x = 6$$

The height cannot be negative, so  $x = 6$ . The dimensions are 6 yards by 26 yards.

46.  $A = \frac{1}{2}b \cdot h$

$$119 = \frac{1}{2}(x + 6)(x + 3)$$

$$238 = x^2 + 3x + 6x + 18$$

$$0 = x^2 + 9x - 220$$

$$0 = (x + 20)(x - 11)$$

$$x + 20 = 0 \quad \text{or} \quad x - 11 = 0$$

$$x = -20 \quad \text{or} \quad x = 11$$

A side length cannot be negative, so  $x = 11$ .

The dimensions are 14 feet by 17 feet.

47.  $x^2 - 4xy + 4y^2 = (x - 2y)(x - 2y)$

48.  $y^2 - 6yz + 5z^2 = (y - 5z)(y - z)$

49.  $c^2 + 13cd + 36d^2 = (c + 9d)(c + 4d)$

50.  $r^2 + 15rs + 50s^2 = (r + 10s)(r + 5s)$

51.  $a^2 + 2ab - 15b^2 = (a + 5b)(a - 3b)$

52.  $x^2 + 8xy - 65y^2 = (x + 13y)(x - 5y)$

53.  $m^2 - mn - 42n^2 = (m - 7n)(m + 6n)$

54.  $u^2 - 3uv - 108v^2 = (u - 12v)(u + 9v)$

55.  $g^2 + 4gh - 60h^2 = (g + 10h)(g - 6h)$

# Chapter 9, continued

56.

Factors of 15	Sum of factors
15, 1	$15 + 1 = 16$
5, 3	$5 + 3 = 8$
-15, -1	$-15 + -1 = -16$
-5, -3	$-5 + -3 = -8$

For  $x^2 + bx + 15$ ,  $b = \pm 16$  or  $\pm 8$ .

57.

Factors of 21	Sum of factors
-21, -1	$-21 + (-1) = -22$
-7, -3	$-7 + (-3) = -10$
21, 1	$21 + 1 = 22$
7, 3	$7 + 3 = 10$

For  $x^2 - bx + 21$ ,  $b = \pm 22$  or  $\pm 10$ .

58.

Factors of -42	Sum of factors
-42, 1	$-42 + 1 = -41$
42, -1	$42 + (-1) = 41$
-21, 2	$-21 + 2 = -19$
21, -2	$21 + (-2) = 19$
-14, 3	$-14 + 3 = -11$
14, -3	$14 + (-3) = 11$
-7, 6	$-7 + 6 = -1$
7, -6	$7 + (-6) = 1$

For  $x^2 + bx - 42$ ,  $b = \pm 41$ ,  $\pm 19$ ,  $\pm 11$ , or  $\pm 1$ .

### Problem Solving

59.  $A = \ell \cdot w$   
 $30 = (s + 1)s$   
 $0 = s^2 + s - 30$   
 $0 = (s + 6)(s - 5)$   
 $s + 6 = 0$  or  $s - 5 = 0$   
 $s = -6$  or  $s = 5$

The width cannot be negative, so  $s = 5$  cm. Area of the border =  $2s = 2(5) = 10$ . The area of the border is 10 square centimeters.

60. a.  $A = \ell \cdot w$   
 $= (x + 50)(x + 32)$   
 $= x^2 + 82x + 1600$   
 b.  $2320 = x^2 + 82x + 1600$   
 $0 = x^2 + 82x - 720$   
 $0 = (x + 90)(x - 8)$   
 $x + 90 = 0$  or  $x - 8 = 0$   
 $x = -90$  or  $x = 8$

The width cannot be negative, so the width of the porch is 8 ft.

61. Area of resulting picture =  $(x - 6)(x - 5)$   
 $20 = x^2 - 11x + 30$   
 $0 = x^2 - 11x + 10$   
 $0 = (x - 10)(x - 1)$   
 $x - 10 = 0$  or  $x - 1 = 0$   
 $x = 10$  or  $x = 1$

Reject  $x = 1$  because it yields lengths  $x - 5$  and  $x - 6$  that are negative. The perimeter of the original square was

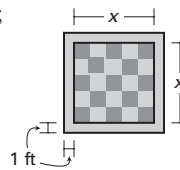
$4x = 4(10) = 40$  inches.

62. a.  $A = 500w + 130w - w^2$   
 $= 630w - w^2$   
 b.  $3125 = 630w - w^2$   
 $w^2 - 630w + 3125 = 0$   
 $(w - 625)(w - 5) = 0$   
 $w - 625 = 0$  or  $w - 5 = 0$   
 $w = 625$  or  $w = 5$

The width is 5 feet.

c. 625 feet does not make sense as a path width in this problem situation because it is wider than the length of either path. In the diagram  $w$  is also the side length of the overlapping square. If  $w = 625$  feet, the square is larger than either part of the path. Only the solution  $w = 5$  ft makes sense as a path width.

63. B;

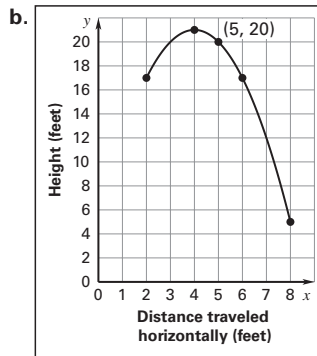


$A = (x + 2)(x + 2)$   
 $25 = x^2 + 4x + 4$   
 $0 = x^2 + 4x - 21$   
 $0 = (x + 7)(x - 3)$   
 $x + 7 = 0$  or  $x - 3 = 0$   
 $x = -7$  or  $x = 3$

The length cannot be negative, so  $x = 3$  feet.

64. a.

$x$	2	4	6	8
$y$	17	21	17	5



c. Yes; your friend is 5 feet away and 20 feet up. Because the projectile's path crosses that point, the keys will reach.

# Chapter 9, continued

d. When  $y = 20$ :

$$20 = -x^2 + 8x + 5$$

$$x^2 - 8x + 15 = 0$$

$$(x - 5)(x - 3) = 0$$

$$x - 5 = 0 \quad \text{or} \quad x - 3 = 0$$

$$x = 5 \quad \text{or} \quad x = 3$$

This shows that the keys reach a height of 20 feet when  $x = 3$  and  $x = 5$ . Your friend is 5 feet away from you, so the solution  $x = 5$  makes sense.

65. a.  $A = \ell \cdot w$

$$120 = (x + 8)(x + 10)$$

$$120 = x^2 + 10x + 8x + 80$$

$$0 = x^2 + 18x - 40$$

$$0 = (x + 20)(x - 2)$$

$$x + 20 = 0 \quad \text{or} \quad x - 2 = 0$$

$$x = -20 \quad \text{or} \quad x = 2$$

A side length cannot be negative, so  $x = 2$ .

The dimensions of the stage are  $x + 10 = 12$  ft by  $x + 8 = 10$  ft.

b.  $A = \ell \cdot w$

$$360 = [(a + 2) + (a + 2) + 10][a + a + 12]$$

$$360 = (2a + 14)(2a + 12)$$

$$360 = 4a^2 + 24a + 28a + 168$$

$$0 = 4a^2 + 52a - 192$$

$$0 = a^2 + 13a - 48$$

$$0 = (a + 16)(a - 3)$$

$$a + 16 = 0 \quad \text{or} \quad a - 3 = 0$$

$$a = -16 \quad \text{or} \quad a = 3$$

Geometric lengths cannot be negative, so  $a = 3$ .

The overall dimensions of the room are  $\ell = (a + 2) + (a + 2) + 10 = 20$  ft by  $w = a + a + 12 = 18$  ft.

## Mixed Review

66.  $x + 12 = 4$

$$x = -8$$

The solution is  $-8$ .

68.  $6n + 4 = -14$

$$6n = -18$$

$$n = -3$$

The solution is  $-3$ .

70.  $3 - 2(w + 7) = -1$

$$3 - 2w - 14 = -1$$

$$-2w - 11 = -1$$

$$-2w = 10$$

$$w = -5$$

The solution is  $-5$ .

67.  $5y - 2 = 13$

$$5y = 15$$

$$y = 3$$

The solution is 3.

69.  $3a - 5a + 12 = -6$

$$-2a + 12 = -6$$

$$-2a = -18$$

$$a = 9$$

The solution is 9.

71.  $-6 + 2(d - 9) = 8d$

$$-6 + 2d - 18 = 8d$$

$$2d - 24 = 8d$$

$$-24 = 6d$$

$$-4 = d$$

The solution is  $-4$ .

72.  $(x - 8)(x + 3) = 0$

$$x - 8 = 0 \quad \text{or} \quad x + 3 = 0$$

$$x = 8 \quad \text{or} \quad x = -3$$

The solutions are 8 and  $-3$ .

73.  $(3t + 5)(t + 2) = 0$

$$3t + 5 = 0 \quad \text{or} \quad t + 2 = 0$$

$$3t = -5 \quad \text{or} \quad t = -2$$

$$t = -\frac{5}{3}$$

The solutions are  $-\frac{5}{3}$  and  $-2$ .

74.  $(3x + 7)(x - 5) = 3x^2 - 15x + 7x - 35$

$$= 3x^2 - 8x - 35$$

75.  $(3a - 4)(2a - 9) = 6a^2 - 27a - 8a + 36$

$$= 6a^2 - 35a + 36$$

76.  $(c + 2)(c^2 + c - 4) = (c + 2)c^2 + (c + 2)c - (c + 2)4$

$$= c^3 + 2c^2 + c^2 + 2c - 4c - 8$$

$$= c^3 + 3c^2 - 2c - 8$$

77.  $(7 + 3y)(7 - 5y) = 49 - 35y + 21y - 15y^2$

$$= 49 - 14y - 15y^2$$

78.  $(2k - 8)(2k + 8) = (2k)^2 - 8^2 = 4k^2 - 64$

79.  $(14 - 2n)^2 = 14^2 - 2(14)(2n) + (2n)^2$

$$= 196 - 56n + 4n^2$$

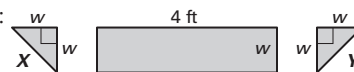
80.  $(5x + 16y)^2 = (5x)^2 + 2(5x)(16y) + (16y)^2$

$$= 25x^2 + 160xy + 256y^2$$

81.  $(3x - 6y)(3x + 6y) = (3x)^2 - (6y)^2 = 9x^2 - 36y^2$

## Problem Solving Workshop 9.5 (p. 591)

1. Method 1:



$$A = \frac{1}{2}w^2 \quad A = 4w \quad A = \frac{1}{2}w^2$$

$w$	Area of triangle X $(\frac{1}{2}w^2)$	Area of rectangle $(4w)$	Area of triangle Y $(\frac{1}{2}w^2)$	Total area $(4w + w^2)$
1	0.5	4	0.5	5
2	2	8	2	12

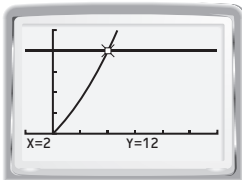
← Too small

← Correct area

## Chapter 9, continued

The width of the counter should be 2 feet.

Method 2: Area = Area of triangle  $X$  + area of rectangle + area of triangle  $Y = \frac{1}{2}w^2 + 4w + \frac{1}{2}w^2 = w^2 + 4w$



Graph  $y_1 = x^2 + 4x$  and  $y_2 = 12$ . The intersection is at  $(2, 12)$ , so the counter has a width of 2 feet.

2. The trinomial was factored incorrectly as  $(w + 2)(w - 6)$  instead of  $(w - 2)(w + 6)$ .

$$12 = 4w + \frac{1}{2}w^2 + \frac{1}{2}w^2$$

$$0 = w^2 + 4w - 12$$

$$0 = (w - 2)(w + 6)$$

$$w - 2 = 0 \quad \text{or} \quad w + 6 = 0$$

$$w = 2 \quad \text{or} \quad w = -6$$

The width is 2 feet.

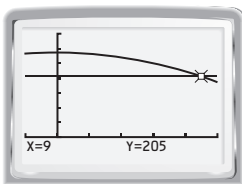
3. Method 1: Area =  $2(11 \cdot 13) - x^2 = 286 - x^2$

$x$	Area of fountain ( $x^2$ )	Total area ( $286 - x^2$ )
5	25	261
6	36	250
7	49	237
8	64	222
9	81	205

← Correct area

The side length of the fountain is 9 ft.

Method 2:  $A = 286 - x^2$ ; graph  $y_1 = 286 - x^2$  and  $y_2 = 205$ .

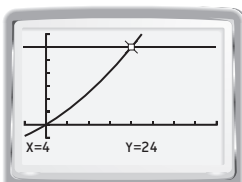


The graphs intersect at  $(9, 205)$ , so the side length of the fountain is 9 feet.

4. Area of banner = Area of triangle + Area of rectangle

$$= \frac{1}{2}w^2 + 4w$$

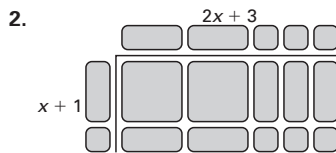
Graph  $y_1 = \frac{1}{2}x^2 + 4x$  and  $y_2 = 24$ .



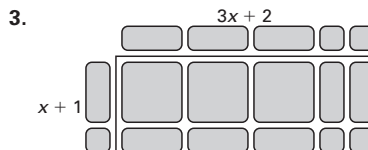
The graph intersects at  $(4, 24)$ . The width of the banner is 4 feet. This answer was found using the graphing method.

### Investigating Algebra Activity 9.6 (p. 592)

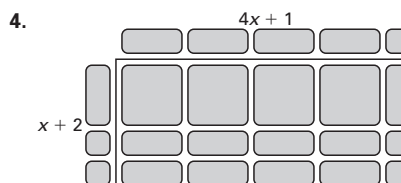
1.  $(x + 3)(2x + 1) = 2x^2 + x + 6x + 3 = 2x^2 + 7x + 3$



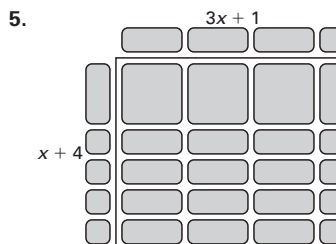
The side lengths of the rectangles represent the polynomials  $2x + 3$  and  $x + 1$ . So,  $2x^2 + 5x + 3 = (2x + 3)(x + 1)$ .



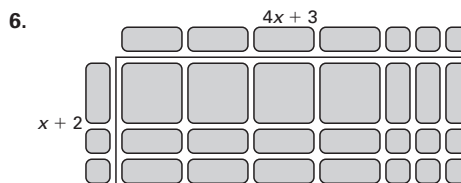
The side lengths of the rectangles represent the polynomials  $3x + 2$  and  $x + 1$ . So,  $3x^2 + 5x + 2 = (3x + 2)(x + 1)$ .



The side lengths of the rectangle represent the polynomials  $4x + 1$  and  $x + 2$ . So,  $4x^2 + 9x + 2 = (4x + 1)(x + 2)$ .



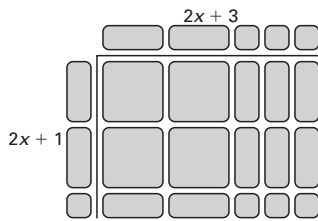
The side lengths of the rectangle represent the polynomials  $3x + 1$  and  $x + 4$ . So,  $3x^2 + 13x + 4 = (3x + 1)(x + 4)$ .



The side lengths of the rectangle represent the polynomials  $4x + 3$  and  $x + 2$ . So,  $4x^2 + 11x + 6 = (4x + 3)(x + 2)$ .

# Chapter 9, continued

7.



The side lengths of the rectangle represent the polynomials  $2x + 3$  and  $2x + 1$ . So,  $4x^2 + 8x + 3 = (2x + 3)(2x + 1)$ .

8.  $2x^2 + 11x + 5 = (2x + 1)(x + 5)$

The leading coefficient of the trinomial is the product of the leading coefficients of its binomial factors.

## Lesson 9.6

### 9.6 Guided Practice (pp. 594–595)

1. Because  $b$  is positive and  $c$  is positive, the factors of  $c$  are positive.

Factors of 3	Factors of 4	Possible factorization	Middle term when multiplied	
1, 3	1, 4	$(t + 1)(3t + 4)$	$7t$	X
1, 3	2, 2	$(t + 2)(3t + 2)$	$8t$	Correct
1, 3	4, 1	$(t + 4)(3t + 1)$	$13t$	X

Solution:  $3t^2 + 8t + 4 = (t + 2)(3t + 2)$

2. Because  $b$  is negative and  $c$  is positive, both factors of  $c$  must be negative.

Factors of 4	Factors of 5	Possible factorization	Middle term when multiplied	
1, 4	-1, -5	$(s - 1)(4s - 5)$	$-9s$	Correct
1, 4	-5, -1	$(s - 5)(4s - 1)$	$-21s$	X
2, 2	-1, -5	$(2s - 1)(2s - 5)$	$-12s$	X

Solution:  $4s^2 - 9s + 5 = (s - 1)(4s - 5)$

3. Because  $b$  is positive and  $c$  is negative, the factors of  $c$  will have opposite signs.

Factors of 2	Factors of -7	Possible factorization	Middle term when multiplied	
1, 2	1, -7	$(h + 1)(2h - 7)$	$-5h$	X
1, 2	-1, 7	$(h - 1)(2h + 7)$	$5h$	X
1, 2	-7, 1	$(h - 7)(2h + 1)$	$-13h$	X
1, 2	7, -1	$(h + 7)(2h - 1)$	$13h$	Correct

Solution:  $2h^2 + 13h - 7 = (h + 7)(2h - 1)$

4.  $-2y^2 - 5y - 3 = -(2y^2 + 5y + 3)$

Because  $b$  and  $c$  are positive, both factors of  $c$  will be positive.

Factors of 2	Factors of 3	Possible factorization	Middle term when multiplied	
1, 2	1, 3	$(y + 1)(2y + 3)$	$5y$	Correct
1, 2	3, 1	$(y + 3)(2y + 1)$	$7y$	X

Solution:  $-2y^2 - 5y - 3 = -(y + 1)(2y + 3)$

5.  $-5m^2 + 6m - 1 = -(5m^2 - 6m + 1)$

Because  $b$  is negative and  $c$  is positive, both factors of  $c$  must be negative.

Factors of 5	Factors of 1	Possible factorization	Middle term when multiplied	
1, 5	-1, -1	$(m - 1)(5m - 1)$	$-6m$	Correct

Solution:  $-5m^2 + 6m - 1 = -(m - 1)(5m - 1)$

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

Because  $b$  is positive and  $c$  is negative, the factors of  $c$  will have opposite signs.

Factors of 3	Factors of -2	Possible factorization	Middle term when multiplied	
1, 3	1, -2	$(x + 1)(3x - 2)$	$x$	Correct
1, 3	-1, 2	$(x - 1)(3x + 2)$	$-x$	X
1, 3	-2, 1	$(x - 2)(3x + 1)$	$-5x$	X
1, 3	2, -1	$(x + 2)(3x - 1)$	$5x$	X

Solution:  $-3x^2 - x + 2 = -(x + 1)(3x - 2)$

7.  $h = -16t^2 + 38t + 5$

$0 = -16t^2 + 38t + 5$

$0 = -(16t^2 - 38t - 5)$

$0 = -(8t + 1)(2t - 5)$

$8t + 1 = 0$  or  $2t - 5 = 0$

$t = -\frac{1}{8}$  or  $t = \frac{5}{2}$

A negative solution does not make sense, so disregard  $-\frac{1}{8}$ . The discus hits the ground after  $\frac{5}{2} = 2.5$  seconds.

8.  $0 = -16t^2 + 29t + 6$

$0 = -(16t^2 - 29t - 6)$

$0 = -(16t + 3)(t - 2)$

$16t + 3 = 0$  or  $t - 2 = 0$

$t = -\frac{3}{16}$  or  $t = 2$

A negative solution does not make sense, so disregard  $-\frac{3}{16}$ . The shot put hits the ground after 2 seconds.

## Chapter 9, continued

$$\begin{aligned}
 9. B; \quad (2w + 1)w &= 6 \\
 2w^2 + w &= 6 \\
 2w^2 + w - 6 &= 0 \\
 (2w - 3)(w + 2) &= 0 \\
 2w - 3 = 0 \quad \text{or} \quad w + 2 = 0 \\
 w = \frac{3}{2} \quad \text{or} \quad w = -2
 \end{aligned}$$

A negative width does not make sense, so disregard  $-2$ .  
The width of the rectangle is  $\frac{3}{2}$  inches.

### 9.6 Skill Practice (pp. 596–599)

- Another word for solution of  $x^2 + 2x + 1 = 0$  is roots.
- To use a graph to check a factorization, plot the original equation and the factored equation on the same axes. If the graphs coincide then the factorization is correct.
- $6x^2 - x - 2 \quad x^2 - x - 2$   
 $(2x + 1)(3x - 2) \quad (x + 1)(x - 2)$   
When factoring  $6x^2 - x - 2$ , you have to consider the factors of the leading coefficients and constant term; when factoring  $x^2 - x - 2$ , you only have to consider the factors of the constant term.
- $-x^2 + x + 20 = -(x^2 - x - 20) = -(x + 4)(x - 5)$
- $-y^2 + 2y + 8 = -(y^2 - 2y - 8) = -(y + 2)(y - 4)$
- $-a^2 + 12a - 27 = -(a^2 - 12a + 27)$   
 $= -(a - 9)(a - 3)$
- $5w^2 - 6w + 1 = (5w - 1)(w - 1)$
- $-3p^2 - 10p - 3 = -(3p^2 + 10p + 3)$   
 $= -(3p + 1)(p + 3)$
- $6s^2 - s - 5 = (6s + 5)(s - 1)$
- $2t^2 + 5t - 63 = (2t - 9)(t + 7)$
- $2c^2 - 7c + 3 = (2c - 1)(c - 3)$
- $3n^2 - 17n + 10 = (3n - 2)(n - 5)$
- $-2h^2 + 5h + 3 = -(2h^2 - 5h - 3)$   
 $= -(2h + 1)(h - 3)$
- $-6k^2 - 13k - 6 = -(6k^2 + 13k + 6)$   
 $= -(2k + 3)(3k + 2)$
- $10x^2 - 3x - 27 = (2x + 3)(5x - 9)$
- $4m^2 + 9m + 5 = (4m + 5)(m + 1)$
- $3z^2 + z - 14 = (3z + 7)(z - 2)$
- $4a^2 + 9a - 9 = (4a - 3)(a + 3)$
- $4n^2 + 16n + 15 = (2n + 3)(2n + 5)$
- $-5b^2 + 7b - 2 = -(5b^2 - 7b + 2)$   
 $= -(5b - 2)(b - 1)$
- $6y^2 - 5y - 4 = (3y - 4)(2y + 1)$
- B;  $8x^2 - 10x + 3 = (2x - 1)(4x - 3)$
- $2x^2 - 3x - 35 = 0$   
 $(2x + 7)(x - 5) = 0$   
 $2x + 7 = 0 \quad \text{or} \quad x - 5 = 0$   
 $x = -\frac{7}{2} \quad \text{or} \quad x = 5$

- $3w^2 + 22w + 7 = 0$   
 $(3w + 1)(w + 7) = 0$   
 $3w + 1 = 0 \quad \text{or} \quad w + 7 = 0$   
 $w = -\frac{1}{3} \quad \text{or} \quad w = -7$
- $4s^2 + 11s - 3 = 0$   
 $(4s - 1)(s + 3) = 0$   
 $4s - 1 = 0 \quad \text{or} \quad s + 3 = 0$   
 $s = \frac{1}{4} \quad \text{or} \quad s = -3$
- $7a^2 + 2a = 5$   
 $7a^2 + 2a - 5 = 0$   
 $(a + 1)(7a - 5) = 0$   
 $a + 1 = 0 \quad \text{or} \quad 7a - 5 = 0$   
 $a = -1 \quad \text{or} \quad a = \frac{5}{7}$
- $8t^2 - 2t = 3$   
 $8t^2 - 2t - 3 = 0$   
 $(2t + 1)(4t - 3) = 0$   
 $2t + 1 = 0 \quad \text{or} \quad 4t - 3 = 0$   
 $t = -\frac{1}{2} \quad \text{or} \quad t = \frac{3}{4}$
- $6m^2 - 5m = 14$   
 $6m^2 - 5m - 14 = 0$   
 $(6m + 7)(m - 2) = 0$   
 $6m + 7 = 0 \quad \text{or} \quad m - 2 = 0$   
 $m = -\frac{7}{6} \quad \text{or} \quad m = 2$
- $b(20b - 3) - 2 = 0$   
 $20b^2 - 3b - 2 = 0$   
 $(4b + 1)(5b - 2) = 0$   
 $4b + 1 = 0 \quad \text{or} \quad 5b - 2 = 0$   
 $b = -\frac{1}{4} \quad \text{or} \quad b = \frac{2}{5}$
- $4(3y^2 - 7y + 4) = 1$   
 $12y^2 - 28y + 16 - 1 = 0$   
 $12y^2 - 28y + 15 = 0$   
 $(6y - 5)(2y - 3) = 0$   
 $6y - 5 = 0 \quad \text{or} \quad 2y - 3 = 0$   
 $y = \frac{5}{6} \quad \text{or} \quad y = \frac{3}{2}$
- $p(3p + 14) = 5$   
 $3p^2 + 14p - 5 = 0$   
 $(p + 5)(3p - 1) = 0$   
 $p + 5 = 0 \quad \text{or} \quad 3p - 1 = 0$   
 $p = -5 \quad \text{or} \quad p = \frac{1}{3}$

## Chapter 9, continued

$$\begin{aligned}
 32. \quad & 4n^2 - 2n - 90 = 0 \\
 & (2n + 9)(2n - 10) = 0 \\
 & 2n + 9 = 0 \quad \text{or} \quad 2n - 10 = 0 \\
 & n = -\frac{9}{2} \quad \text{or} \quad n = 5
 \end{aligned}$$

$$\begin{aligned}
 33. \quad & 10c^2 - 14c + 4 = 0 \\
 & (5c - 2)(2c - 2) = 0 \\
 & 5c - 2 = 0 \quad \text{or} \quad 2c - 2 = 0 \\
 & c = \frac{2}{5} \quad \text{or} \quad c = 1
 \end{aligned}$$

$$\begin{aligned}
 34. \quad & -16k^2 + 8k + 24 = 0 \\
 & -4(4k^2 - 2k - 6) = 0 \\
 & -4(2k - 3)(2k + 2) = 0 \\
 & 2k - 3 = 0 \quad \text{or} \quad 2k + 2 = 0 \\
 & k = \frac{3}{2} \quad \text{or} \quad k = -1
 \end{aligned}$$

$$\begin{aligned}
 35. \quad & 6r^2 - 15r = 99 \\
 & 6r^2 - 15r - 99 = 0 \\
 & (2r - 11)(3r + 9) = 0 \\
 & 2r - 11 = 0 \quad \text{or} \quad 3r + 9 = 0 \\
 & r = \frac{11}{2} \quad \text{or} \quad r = -3
 \end{aligned}$$

$$\begin{aligned}
 36. \quad & 56z^2 + 2 = 22z \\
 & 56z^2 - 22z + 2 = 0 \\
 & 2(28z^2 - 11z + 1) = 0 \\
 & 2(7z - 1)(4z - 1) = 0 \\
 & 7z - 1 = 0 \quad \text{or} \quad 4z - 1 = 0 \\
 & z = \frac{1}{7} \quad \text{or} \quad z = \frac{1}{4}
 \end{aligned}$$

$$\begin{aligned}
 37. \quad & 30x^2 + 25x = 20 \\
 & 30x^2 + 25x - 20 = 0 \\
 & 5(6x^2 + 5x - 4) = 0 \\
 & 5(3x + 4)(2x - 1) = 0 \\
 & 3x + 4 = 0 \quad \text{or} \quad 2x - 1 = 0 \\
 & x = -\frac{4}{3} \quad \text{or} \quad x = \frac{1}{2}
 \end{aligned}$$

38. The equation was not first rewritten in the form  $ax^2 + bx + c = 0$ .

$$\begin{aligned}
 & 5x^2 + x = 4 \\
 & 5x + x - 4 = 0 \\
 & (5x - 4)(x + 1) = 0 \\
 & 5x - 4 = 0 \quad \text{or} \quad x + 1 = 0 \\
 & x = \frac{4}{5} \quad \text{or} \quad x = -1
 \end{aligned}$$

39. In the second step, the factors were set up incorrectly.

$$\begin{aligned}
 & 12x^2 + 5x - 2 = 0 \\
 & (4x - 1)(3x + 2) = 0 \\
 & 4x - 1 = 0 \quad \text{or} \quad 3x + 2 = 0 \\
 & x = \frac{1}{4} \quad \text{or} \quad x = -\frac{2}{3}
 \end{aligned}$$

$$\begin{aligned}
 40. \quad & 6 = (5w + 7)w \\
 & 0 = 5w^2 + 7w - 6 \\
 & 0 = (5w - 3)(w + 2) \\
 & 5w - 3 = 0 \quad \text{or} \quad w + 2 = 0 \\
 & w = \frac{3}{5} \quad \text{or} \quad w = -2
 \end{aligned}$$

The width can't be negative, so the width is  $\frac{3}{5}$  inch.

$$\begin{aligned}
 41. \quad & 3 = (4w + 1)w \\
 & 0 = 4w^2 + w - 3 \\
 & 0 = (4w - 3)(w + 1) \\
 & 4w - 3 = 0 \quad \text{or} \quad w + 1 = 0 \\
 & w = \frac{3}{4} \quad \text{or} \quad w = -1
 \end{aligned}$$

Reject the negative width.

$$\begin{aligned}
 \text{Perimeter} &= 2l + 2w \\
 &= 2(4w + 1) + 2w \\
 &= 8w + 2 + 2w \\
 &= 10w + 2 \\
 &= 10\left(\frac{3}{4}\right) + 2 = \frac{19}{2} = 9\frac{1}{2}
 \end{aligned}$$

The perimeter is  $9\frac{1}{2}$  inches.

$$\begin{aligned}
 42. \quad & g(x) = 2x^2 + x - 1 \\
 & 0 = (2x - 1)(x + 1) \\
 & 2x - 1 = 0 \quad \text{or} \quad x + 1 = 0 \\
 & x = \frac{1}{2} \quad \text{or} \quad x = -1
 \end{aligned}$$

$$\begin{aligned}
 43. \quad & f(x) = -x^2 + 12x - 35 \\
 & 0 = -(x - 12x + 35) \\
 & 0 = -(x - 5)(x - 7) \\
 & x - 5 = 0 \quad \text{or} \quad x - 7 = 0 \\
 & x = 5 \quad \text{or} \quad x = 7
 \end{aligned}$$

$$\begin{aligned}
 44. \quad & h(x) = -3x^2 + 2x + 5 \\
 & 0 = -(3x^2 - 2x - 5) \\
 & 0 = -(3x - 5)(x + 1) \\
 & 3x - 5 = 0 \quad \text{or} \quad x + 1 = 0 \\
 & x = \frac{5}{3} \quad \text{or} \quad x = -1
 \end{aligned}$$

$$\begin{aligned}
 45. \quad & f(x) = 3x^2 + x - 14 \\
 & 0 = (3x + 7)(x - 2) \\
 & 3x + 7 = 0 \quad \text{or} \quad x - 2 = 0 \\
 & x = -\frac{7}{3} \quad \text{or} \quad x = 2
 \end{aligned}$$

$$\begin{aligned}
 46. \quad & g(x) = 8x^2 - 6x - 14 \\
 & 0 = 2(4x^2 - 3x - 7) \\
 & 0 = 2(x + 1)(4x - 7) \\
 & x + 1 = 0 \quad \text{or} \quad 4x - 7 = 0 \\
 & x = -1 \quad \text{or} \quad x = \frac{7}{4}
 \end{aligned}$$

## Chapter 9, continued

$$\begin{aligned}
 47. \quad f(x) &= 12x^2 - 24x - 63 \\
 0 &= 3(4x^2 - 8x - 21) \\
 0 &= 3(2x - 7)(2x + 3) \\
 2x - 7 &= 0 \quad \text{or} \quad 2x + 3 = 0 \\
 x &= \frac{7}{2} \quad \text{or} \quad x = -\frac{3}{2}
 \end{aligned}$$

$$\begin{aligned}
 48. \quad 0.3x^2 - 0.7x - 4.0 &= 0 \\
 10(0.3x^2 - 0.7x - 4.0) &= 0 \\
 3x^2 - 7x - 40 &= 0 \\
 (3x + 8)(x - 5) &= 0 \\
 3x + 8 = 0 \quad \text{or} \quad x - 5 = 0 \\
 x = -\frac{8}{3} \quad \text{or} \quad x &= 5
 \end{aligned}$$

$$\begin{aligned}
 49. \quad 0.8x^2 - 1.8x - 0.5 &= 0 \\
 10(0.8x^2 - 1.8x - 0.5) &= 0 \\
 8x^2 - 18x - 5 &= 0 \\
 (4x + 1)(2x - 5) &= 0 \\
 4x + 1 = 0 \quad \text{or} \quad 2x - 5 = 0 \\
 x = -\frac{1}{4} \quad \text{or} \quad x &= \frac{5}{2}
 \end{aligned}$$

$$\begin{aligned}
 50. \quad 0.4x^2 - 0.4x &= 9.9 \\
 0.4x^2 - 0.4x - 9.9 &= 0 \\
 10(0.4x^2 - 0.4x - 9.9) &= 0 \\
 4x^2 - 4x - 99 &= 0 \\
 (2x + 9)(2x - 11) &= 0 \\
 2x + 9 = 0 \quad \text{or} \quad 2x - 11 = 0 \\
 x = -\frac{9}{2} \quad \text{or} \quad x &= \frac{11}{2}
 \end{aligned}$$

$$\begin{aligned}
 51. \quad C; \quad 0.4x^2 - 1.1x &= 2 \\
 0.4x^2 - 1.1x - 2 &= 0 \\
 10(0.4x^2 - 1.1x - 2) &= 0 \\
 4x^2 - 11x - 20 &= 0 \\
 (4x + 5)(x - 4) &= 0 \\
 4x + 5 = 0 \quad \text{or} \quad x - 4 = 0 \\
 x = -\frac{5}{4} \quad \text{or} \quad x &= 4
 \end{aligned}$$

$$\begin{aligned}
 52. \quad (x + 3)(x - 2) &= 0 \\
 x^2 - 2x + 3x - 6 &= 0 \\
 x^2 + x - 6 &= 0
 \end{aligned}$$

Knowing the solutions, two binomials can be formed, multiplied and set equal to zero.

$$\begin{aligned}
 53. \quad \left(x + \frac{1}{2}\right)(x - 5) &= 0 \\
 (2x + 1)(x - 5) &= 0 \\
 2x^2 - 10x + x - 5 &= 0 \\
 2x^2 - 9x - 5 &= 0
 \end{aligned}$$

Knowing the solutions, two binomials can be formed, multiplied, and set equal to zero.

$$\begin{aligned}
 54. \quad \left(x + \frac{3}{4}\right)\left(x + \frac{1}{3}\right) &= 0 \\
 (4x + 3)(3x + 1) &= 0 \\
 12x^2 + 4x + 9x + 3 &= 0 \\
 12x^2 + 13x + 3 &= 0
 \end{aligned}$$

Knowing the solutions, two binomials can be formed, multiplied, and set equal to zero.

$$\begin{aligned}
 55. \quad 2x^2 - 11xy + 5y^2 &= (2x - y)(x - 5y) \\
 56. \quad 3x^2 + 2xy - 8y^2 &= (3x - 4y)(x + 2y) \\
 57. \quad 6x^3 - 10x^2y - 56xy^2 &= 2x(3x^2 - 5xy - 28y^2) \\
 &= 2x(3x + 7y)(x - 4y)
 \end{aligned}$$

### Problem Solving

$$58. \text{ Let } h = 0, v = 28, \text{ and } s = 32.$$

$$\begin{aligned}
 h &= -16t^2 + vt + s \\
 0 &= -16t^2 + 28t + 32 \\
 0 &= -4(4t^2 - 7t - 8) \\
 t &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\
 t &= \frac{-(-7) \pm \sqrt{(-7)^2 - 4(4)(-8)}}{2(4)} \\
 t &\approx 2.54 \quad \text{or} \quad t \approx -0.788 \frac{2}{3}
 \end{aligned}$$

Reject the negative solution. Your center of gravity enters the water after about 2.54 seconds.

$$\begin{aligned}
 59. \quad \text{a. Area} &= \text{length} \cdot \text{width} \\
 &= (2 + 3(2x) + 2(1) + 2)(2 + 4x + 2) \\
 &= (6x + 6)(4x + 4) \\
 &= 24x^2 + 48x + 24
 \end{aligned}$$

$$\begin{aligned}
 \text{b. } 24x^2 + 48x + 24 &= 96 \\
 24x^2 + 48x - 72 &= 0 \\
 24(x^2 + 2x - 3) &= 0 \\
 24(x - 1)(x + 3) &= 0 \\
 x = 1 \quad \text{or} \quad x &= -3
 \end{aligned}$$

Reject the negative solution. The pictures will be  $2x = 2$  centimeters wide and  $4x = 4$  centimeters long.

$$\begin{aligned}
 60. \quad \text{You can use the vertical motion model to write an equation for the height (in feet) of the ball. Let } v &= 31 \text{ because the initial velocity is 31 feet per second, let } s = 6 \text{ because the initial height is 6 feet, and let } h = 4 \text{ because you catch the ball at a height of 4 feet. Solving this equation for } t \text{ will give the time (in seconds) that the ball is in the air before it is caught.}
 \end{aligned}$$

$$\begin{aligned}
 h &= -16t^2 + vt + s \\
 4 &= -16t^2 + 31t + 6 \\
 0 &= -16t^2 + 31t + 2 \\
 0 &= -(16t^2 - 31t - 2) \\
 0 &= -(16t + 1)(t - 2) \\
 16t + 1 = 0 \quad \text{or} \quad t - 2 &= 0 \\
 t &= -\frac{1}{16} \quad \text{or} \quad t = 2
 \end{aligned}$$

# Chapter 9, continued

A negative solution does not make sense in this situation, so disregard  $-\frac{1}{16}$ . You catch the ball after 2 seconds.

61.  $A = (2w + 8)w$

$$2170 = 2w^2 + 8w$$

$$0 = 2w^2 + 8w - 2170$$

$$0 = 2(w^2 + 4w - 1085)$$

$$0 = 2(w - 31)(w + 35)$$

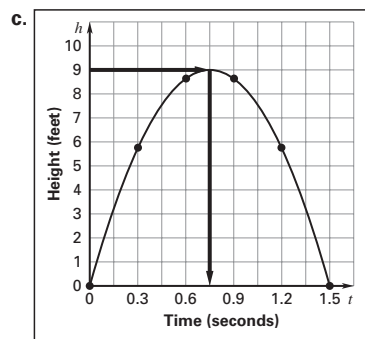
$$w = 31 \quad \text{or} \quad w = -35$$

Reject the negative width. The width is 31 meters and the length is  $\ell = 2w + 8 = 70$  meters.

62. a.  $h = -16t^2 + 24t$

b.

$t$	0	0.3	0.6	0.9	1.2	1.5
$h$	0	5.76	8.64	8.64	5.76	0



From the graph, you can estimate that the serval reaches a height of 9 feet after about 0.75 seconds. Using the equation from part (a), let  $h = 9$ .

$$h = -16t^2 + 24t$$

$$9 = -16t^2 + 24t$$

$$0 = -16t^2 + 24t - 9$$

$$0 = -(16t^2 - 24t + 9)$$

$$0 = -(4t - 3)(4t - 3)$$

$$4t - 3 = 0$$

$$t = \frac{3}{4} \quad \text{or} \quad 0.75$$

63. a.  $h = -16t^2 + 4t$

b.  $3 \text{ in.} \cdot \frac{1 \text{ ft}}{12 \text{ in.}} = \frac{1}{4} \text{ ft}$

$$\frac{1}{4} = -16t^2 + 4t$$

$$0 = \left(-16t^2 + 4t - \frac{1}{4}\right)4$$

$$0 = -64t^2 + 16t - 1$$

$$0 = -(64t^2 - 16t + 1)$$

$$0 = -(8t - 1)(8t - 1)$$

$$8t - 1 = 0$$

$$t = \frac{1}{8}$$

The cricket is 3 inches off the ground after  $\frac{1}{8}$  second.

c. No; because the solution in part(b) gives only one value of  $t$ , the cricket reaches a height of 3 inches only once. This happens only at the highest point of the cricket's jump; all other heights are reached twice, once on the way up and once on the way down.

## Mixed Review

64.  $b - 9 = 18; 3$

$$3 - 9 \stackrel{?}{=} 18$$

$$-6 \neq 18 \quad \text{Not a solution}$$

65.  $8 - 3h = 2; 2$

$$8 - 3(2) \stackrel{?}{=} 2$$

$$2 = 2 \quad \checkmark \quad \text{Solution}$$

66.  $\frac{28 - 2x}{x} < 5; 4$

$$\frac{28 - 2(4)}{4} \stackrel{?}{<} 5$$

$$5 < 5 \quad \text{Not a solution}$$

67.  $6t + 18 = 0; -3$

$$6(-3) + 18 \stackrel{?}{=} 0$$

$$0 = 0 \quad \checkmark \quad \text{Solution}$$

68.  $6c = 3c; 2$

$$6(2) \stackrel{?}{=} 3(2)$$

$$12 \neq 6 \quad \text{Not a Solution}$$

69.  $|x + 3| = 2; -5$

$$|-5 + 3| \stackrel{?}{=} 2$$

$$2 = 2 \quad \checkmark \quad \text{Solution}$$

70.  $|y - 2| + 6 = 5; 1$

$$|1 - 2| + 6 \stackrel{?}{=} 5$$

$$7 \neq 5 \quad \text{Not a solution}$$

71.  $|3n - 11| < 1; 2$

$$|3(2) - 11| \stackrel{?}{<} 1$$

$$5 < 1 \quad \text{Not a solution}$$

72.  $4|3a - 8| > 2; 3$

$$4|3(3) - 8| \stackrel{?}{>} 2$$

$$4 > 2 \quad \checkmark \quad \text{Solution}$$

73.  $(a - 9)^2 = a^2 - 2(9)a + (9)^2 = a^2 - 18a + 81$

74.  $(k + 12)^2 = k^2 + 2(12)k + 12^2 = k^2 + 24k + 144$

75.  $(3x - 2)^2 = (3x)^2 - 2(2)(3x) + (2)^2 = 9x^2 - 12x + 4$

76.  $(m + 4)(m - 4) = m^2 - 4^2 = m^2 - 16$

77.  $(2c + 1)(2c - 1) = (2c)^2 - 1^2 = 4c^2 - 1$

78.  $(5n - 3)(5n + 3) = (5n)^2 - 3^2 = 25n^2 - 9$

79.  $(8 - 3y)^2 = 8^2 - 2(3y)8 + (3y)^2 = 64 - 48y + 9y^2$

80.  $(2s - 5t)^2 = (2s)^2 - 2(2s)(5t) + (5t)^2$   
 $= 4s^2 - 20st + 25t^2$

81.  $(x + 2y)(x - 2y) = x^2 - (2y)^2 = x^2 - 4y^2$

## Quiz 9.4–9.6 (p. 599)

1.  $16a^2 - 40b = 8(2a^2 - 5b)$

2.  $9xy^2 + 6x^2y = 3xy(3y + 2x)$

3.  $4n^4 - 22n^3 - 8n^2 = 2n^2(2n^2 - 11n - 4)$

## Chapter 9, continued

4.  $3x^2 + 6xy - 3y^2 = 3(x^2 + 2xy - y^2)$
5.  $12abc^2 - 6a^2c = 6ac(2bc - a)$
6.  $-36s^3 + 18s^2 - 54s = -18s(2s^2 - s + 3)$
7.  $r^2 + 15r + 56 = (r + 7)(r + 8)$
8.  $s^2 - 6s + 5 = (s - 1)(s - 5)$
9.  $w^2 + 6w - 40 = (w + 10)(w - 4)$
10.  $-a^2 + 9a + 22 = -(a^2 - 9a - 22)$   
 $= -(a + 2)(a - 11)$
11.  $2x^2 - 9x + 4 = (2x - 1)(x - 4)$
12.  $5m^2 + m - 6 = (5m + 6)(m - 1)$
13.  $6h^2 - 19h + 3 = (6h - 1)(h - 3)$
14.  $-7y^2 - 23y - 6 = -(7y^2 + 23y + 6)$   
 $= -(7y + 2)(y + 3)$
15.  $18c^2 + 12c - 6 = 6(3c^2 + 2c - 1) = 6(3c - 1)(c + 1)$
16.  $(4p - 7)(p + 5) = 0$   
 $4p - 7 = 0$  or  $p + 5 = 0$   
 $p = \frac{7}{4}$  or  $p = -5$
17.  $-8u^2 + 28u = 0$   
 $-4u(2u - 7) = 0$   
 $-4u = 0$  or  $2u - 7 = 0$   
 $u = 0$  or  $u = \frac{7}{2}$
18.  $51x^2 = -17x$   
 $51x^2 + 17x = 0$   
 $17x(3x + 1) = 0$   
 $17x = 0$  or  $3x + 1 = 0$   
 $x = 0$  or  $x = -\frac{1}{3}$
19.  $b^2 - 11b = -24$   
 $b^2 - 11b + 24 = 0$   
 $(b - 8)(b - 3) = 0$   
 $b - 8 = 0$  or  $b - 3 = 0$   
 $b = 8$  or  $b = 3$
20.  $m^2 + 12m = -35$   
 $m^2 + 12m + 35 = 0$   
 $(m + 7)(m + 5) = 0$   
 $m + 7 = 0$  or  $m + 5 = 0$   
 $m = -7$  or  $m = -5$
21.  $q^2 + 19 = -20q$   
 $q^2 + 20q + 19 = 0$   
 $(q + 1)(q + 19) = 0$   
 $q + 1 = 0$  or  $q + 19 = 0$   
 $q = -1$  or  $q = -19$
22.  $3t^2 - 11t + 10 = 0$   
 $(3t - 5)(t - 2) = 0$   
 $3t - 5 = 0$  or  $t - 2 = 0$   
 $t = \frac{5}{3}$  or  $t = 2$

23.  $4y^2 + 31y = 8$   
 $4y^2 + 31y - 8 = 0$   
 $(4y - 1)(y + 8) = 0$   
 $4y - 1 = 0$  or  $y + 8 = 0$   
 $y = \frac{1}{4}$  or  $y = -8$

24.  $14s^2 + 12s = 2$   
 $14s^2 + 12s - 2 = 0$   
 $2(7s^2 + 6s - 1) = 0$   
 $2(7s - 1)(s + 1) = 0$   
 $7s - 1 = 0$  or  $s + 1 = 0$   
 $s = \frac{1}{7}$  or  $s = -1$

25. a.  $h = -16t^2 + 72t + 3$

b.  $84 = -16t^2 + 72t + 3$

$$0 = -16t^2 + 72t - 81$$

$$0 = -(16t^2 - 72t + 81)$$

$$0 = -(4t - 9)(4t - 9)$$

$$4t - 9 = 0$$

$$t = \frac{9}{4}$$

The ball is 84 feet above the ground after  $\frac{9}{4} = 2.25$  seconds.

### 9.7 Guided Practice (pp. 600–601)

1.  $4y^2 - 64 = (2y)^2 - 8^2 = (2y + 8)(2y - 8)$

2.  $h^2 + 4h + 4 = h^2 + 2(h \cdot 2) + 2^2 = (h + 2)^2$

3.  $2y^2 - 20y + 50 = 2(y^2 - 10y + 25)$   
 $= 2(y^2 - 2(y \cdot 5) + 5^2)$   
 $= 2(y - 5)^2$

4.  $3x^2 + 6xy + 3y^2 = 3(x^2 + 2xy + y^2) = 3(x + y)^2$

5.  $a^2 + 6a + 9 = 0$

$$a^2 + 2(a \cdot 3) + 3^2 = 0$$

$$(a + 3)^2 = 0$$

$$a + 3 = 0$$

$$a = -3$$

6.  $w^2 - 14w + 49 = 0$

$$w^2 - 2(w \cdot 7) + 7^2 = 0$$

$$(w - 7)^2 = 0$$

$$w - 7 = 0$$

$$w = 7$$

7.  $n^2 - 81 = 0$

$$n^2 - 9^2 = 0$$

$$(n + 9)(n - 9) = 0$$

$$n + 9 = 0 \quad \text{or} \quad n - 9 = 0$$

$$n = -9 \quad \text{or} \quad n = 9$$

## Chapter 9, continued

$$8. 0 = -16t^2 + 16$$

$$0 = -16(t^2 - 1)$$

$$0 = -16(t + 1)(t - 1)$$

$$t + 1 = 0 \quad \text{or} \quad t - 1 = 0$$

$$t = -1 \quad \text{or} \quad t = 1$$

Disregard the negative solution. The sponge lands on the ground 1 second after it is dropped.

### 9.7 Exercises (pp. 602–605)

#### Skill Practice

- The polynomial  $9n^2 + 6n + 1$  is called a *perfect square trinomial*.
- Write the binomial in the form  $a^2 - b^2$  and then factor it as  $(a + b)(a - b)$ .
- $x^2 - 25 = (x + 5)(x - 5)$
- $n^2 - 64 = n^2 - 8^2 = (n + 8)(n - 8)$
- $81c^2 - 4 = (9c)^2 - 2^2 = (9c + 2)(9c - 2)$
- $49 - 121p^2 = 7^2 - (11p)^2 = (7 + 11p)(7 - 11p)$
- $-3m^2 + 48n^2 = -3(m^2 - 16n^2) = -3(m^2 - (4n)^2)$   
 $= -3(m + 4n)(m - 4n)$
- $225x^2 - 144y^2 = (15x)^2 - (12y)^2$   
 $= (15x + 12y)(15x - 12y)$
- $x^2 - 4x + 4 = x^2 - 2(x \cdot 2) + 2^2 = (x - 2)^2$
- $y^2 - 10y + 25 = y^2 - 2(y \cdot 5) + 5^2 = (y - 5)^2$
- $49a^2 + 14a + 1 = (7a)^2 + 2(7a \cdot 1) + 1^2 = (7a + 1)^2$
- $9t^2 - 12t + 4 = (3t)^2 - 2(3t \cdot 2) + 2^2 = (3t - 2)^2$
- $m^2 + m + \frac{1}{4} = m^2 + 2\left(m \cdot \frac{1}{2}\right) + \left(\frac{1}{2}\right)^2 = \left(m + \frac{1}{2}\right)^2$
- $2x^2 + 12xy + 18y^2 = 2(x^2 + 6xy + 9y^2)$   
 $= 2(x^2 + 2(x \cdot 3y) + (3y)^2)$   
 $= 2(x + 3y)^2$
- $4c^2 - 400 = 4(c^2 - 100) = 4(c^2 - 10^2)$   
 $= 4(c - 10)(c + 10)$
- $4f^2 - 36f + 81 = (2f)^2 - 2(2f \cdot 9) + 9^2 = (2f - 9)^2$
- $-9r^2 + 4s^2 = -(9r^2 - 4s^2) = -((3r)^2 - (2s)^2)$   
 $= -(3r + 2s)(3r - 2s)$
- $z^2 + 12z + 36 = z^2 + 2(z \cdot 6) + 6^2 = (z + 6)^2$
- $72 - 32y^2 = 8(9 - 4y^2) = 8(3^2 - (2y)^2)$   
 $= 8(3 + 2y)(3 - 2y)$
- $45r^2 - 120rs + 80s^2 = 5(9r^2 - 24rs + 16s^2)$   
 $= 5((3r)^2 - 2(3r \cdot 4s) + (4s)^2)$   
 $= 5(3r - 4s)^2$
- The result is the difference of two squares, not a perfect square trinomial.  
 $36x^2 - 81 = 9(4x^2 - 9)$   
 $= 9((2x)^2 - 3^2)$   
 $= 9(2x + 3)(2x - 3)$

- The result is a perfect square trinomial, not the difference of two squares.

$$y^2 - 6y + 9 = y^2 - 2(y \cdot 3) + 3^2 = (y - 3)^2$$

- C;  $-45x^2 + 20y^2 = -5(9x^2 - 4y^2) = -5((3x)^2 - (2y)^2)$   
 $= -5(3x + 2y)(3x - 2y)$

- A;  $16m^2 - 8mn + n^2 = (4m)^2 - 2(4m \cdot n) + n^2$   
 $= (4m - n)^2$

$$25. \quad x^2 + 8x + 16 = 0$$

$$x^2 + 2(x \cdot 4) + 4^2 = 0$$

$$(x + 4)^2 = 0$$

$$x + 4 = 0$$

$$x = -4$$

$$26. \quad 16a^2 - 8a + 1 = 0$$

$$(4a)^2 - 2(4a \cdot 1) + 1^2 = 0$$

$$(4a - 1)^2 = 0$$

$$4a - 1 = 0$$

$$a = \frac{1}{4}$$

$$27. \quad 4w^2 - 36 = 0$$

$$(2w)^2 - (6)^2 = 0$$

$$(2w + 6)(2w - 6) = 0$$

$$2w + 6 = 0 \quad \text{or} \quad 2w - 6 = 0$$

$$w = -3 \quad \text{or} \quad w = 3$$

$$28. \quad 32 - 18m^2 = 0$$

$$2(16 - 9m^2) = 0$$

$$2((4)^2 - (3m)^2) = 0$$

$$2(4 + 3m)(4 - 3m) = 0$$

$$4 + 3m = 0 \quad \text{or} \quad 4 - 3m = 0$$

$$m = -\frac{4}{3} \quad \text{or} \quad m = \frac{4}{3}$$

$$29. \quad 27c^2 + 108c + 108 = 0$$

$$27(c^2 + 4c + 4) = 0$$

$$27(c^2 + 2(c \cdot 2) + 2^2) = 0$$

$$27(c + 2)^2 = 0$$

$$c + 2 = 0$$

$$c = -2$$

$$30. \quad -2h^2 - 28h - 98 = 0$$

$$-2(h^2 + 14h + 49) = 0$$

$$-2(h^2 + 2(h \cdot 7) + 7^2) = 0$$

$$-2(h + 7)^2 = 0$$

$$h + 7 = 0$$

$$h = -7$$

## Chapter 9, continued

$$\begin{aligned}
 31. \quad & 6p^2 = 864 \\
 & 6p^2 - 864 = 0 \\
 & 6(p^2 - 144) = 0 \\
 & 6(p^2 - 12^2) = 0 \\
 & 6(p + 12)(p - 12) = 0 \\
 & p + 12 = 0 \quad \text{or} \quad p - 12 = 0 \\
 & p = -12 \quad \text{or} \quad p = 12
 \end{aligned}$$

$$\begin{aligned}
 32. \quad & -3t^2 = -108 \\
 & -3t^2 + 108 = 0 \\
 & -3(t^2 - 36) = 0 \\
 & -3(t^2 - 6^2) = 0 \\
 & -3(t + 6)(t - 6) = 0 \\
 & t + 6 = 0 \quad \text{or} \quad t - 6 = 0 \\
 & t = -6 \quad \text{or} \quad t = 6
 \end{aligned}$$

$$\begin{aligned}
 33. \quad & 8k^2 = 98 \\
 & 8k^2 - 98 = 0 \\
 & 2(4k^2 - 49) = 0 \\
 & 2((2k)^2 - 7^2) = 0 \\
 & 2(2k + 7)(2k - 7) = 0 \\
 & 2k + 7 = 0 \quad \text{or} \quad 2k - 7 = 0 \\
 & k = -\frac{7}{2} \quad \text{or} \quad k = \frac{7}{2}
 \end{aligned}$$

$$\begin{aligned}
 34. \quad & -\frac{4}{3}x + \frac{4}{9} = -x^2 \\
 & x^2 - \frac{4}{3}x + \frac{4}{9} = 0 \\
 & x^2 - 2\left(x \cdot \frac{2}{3}\right) + \left(\frac{2}{3}\right)^2 = 0 \\
 & \left(x - \frac{2}{3}\right)^2 = 0 \\
 & x - \frac{2}{3} = 0 \\
 & x = \frac{2}{3}
 \end{aligned}$$

$$\begin{aligned}
 35. \quad & y^2 - \frac{5}{3}y = \frac{-25}{36} \\
 & y^2 - \frac{5}{3}y + \frac{25}{36} = 0 \\
 & y^2 - 2\left(y \cdot \frac{5}{6}\right) + \left(\frac{5}{6}\right)^2 = 0 \\
 & \left(y - \frac{5}{6}\right)^2 = 0 \\
 & y - \frac{5}{6} = 0 \\
 & y = \frac{5}{6}
 \end{aligned}$$

$$\begin{aligned}
 36. \quad & \frac{2}{9} = 8n^2 \\
 & \frac{2}{9} - 8n^2 = 0 \\
 & 2\left(\frac{1}{9} - 4n^2\right) = 0 \\
 & 2\left(\left(\frac{1}{3}\right)^2 - (2n)^2\right) = 0 \\
 & 2\left(\frac{1}{3} + 2n\right)\left(\frac{1}{3} - 2n\right) = 0 \\
 & \frac{1}{3} + 2n = 0 \quad \text{or} \quad \frac{1}{3} - 2n = 0 \\
 & n = -\frac{1}{6} \quad \text{or} \quad n = \frac{1}{6}
 \end{aligned}$$

$$\begin{aligned}
 37. \quad & -9c^2 = -16 \\
 & 9c^2 - 16 = 0 \\
 & (3c)^2 - (4)^2 = 0 \\
 & (3c + 4)(3c - 4) = 0 \\
 & 3c + 4 = 0 \quad \text{or} \quad 3c - 4 = 0 \\
 & c = -\frac{4}{3} \quad \text{or} \quad c = \frac{4}{3}
 \end{aligned}$$

$$\begin{aligned}
 38. \quad & -20s - 3 = 25s^2 + 1 \\
 & -25s^2 - 20s - 4 = 0 \\
 & -(25s^2 + 20s + 4) = 0 \\
 & -((5s)^2 + 2(5s \cdot 2) + 2^2) = 0 \\
 & -(5s + 2)^2 = 0 \\
 & 5s + 2 = 0 \\
 & s = -\frac{2}{5}
 \end{aligned}$$

$$\begin{aligned}
 39. \quad & y^4 - 2y^3 + y^2 = 0 \\
 & y^2(y^2 - 2y + 1) = 0 \\
 & y^2(y^2 - 2(y \cdot 1) + 1^2) = 0 \\
 & y^2(y - 1)^2 = 0 \\
 & y^2 = 0 \quad \text{or} \quad y - 1 = 0 \\
 & y = 0 \quad \text{or} \quad y = 1
 \end{aligned}$$

$$\begin{aligned}
 40. \quad & x^2 + kx + 36 = x^2 \pm 2(x \cdot 6) + 6^2 \\
 & kx = \pm 2(x \cdot 6) \\
 & kx = \pm 12x \\
 & k = \pm 12
 \end{aligned}$$

$$\begin{aligned}
 41. \quad & 4x^2 + kx + 9 = (2x)^2 \pm 2(2x \cdot 3) + 3^2 \\
 & kx = \pm 2(2x \cdot 3) \\
 & kx = \pm 12x \\
 & k = \pm 12
 \end{aligned}$$

$$\begin{aligned}
 42. \quad & 16x^2 + kx + 4 = (4x)^2 \pm 2(4x \cdot 2) + 2^2 \\
 & kx = \pm 2(4x \cdot 2) \\
 & kx = \pm 16x \\
 & k = \pm 16
 \end{aligned}$$

## Chapter 9, continued

$$43. 25x^2 + 10x + k = (5x)^2 + 2(5x \cdot \sqrt{k}) + (\sqrt{k})^2$$

$$10x = 2(5x \cdot \sqrt{k})$$

$$10x = 10x \sqrt{k}$$

$$1 = \sqrt{k}$$

$$1 = k$$

$$44. 49x^2 - 84x + k = (7x)^2 - 2(7x \cdot \sqrt{k}) + (\sqrt{k})^2$$

$$-84x = -2(7x \cdot \sqrt{k})$$

$$-84x = -14x \sqrt{k}$$

$$6 = \sqrt{k}$$

$$36 = k$$

$$45. 4x^2 - 48x + k = (2x)^2 - 2(2x \cdot \sqrt{k}) + (\sqrt{k})^2$$

$$-48x = -2(2x \cdot \sqrt{k})$$

$$-48x = -4x \sqrt{k}$$

$$12 = \sqrt{k}$$

$$144 = k$$

### Problem Solving

$$46. h = -16t^2 + 25$$

$$0 = -((4t)^2 - 5^2)$$

$$0 = -(4t + 5)(4t - 5)$$

$$4t + 5 = 0 \quad \text{or} \quad 4t - 5 = 0$$

$$t = -\frac{5}{4} \quad \text{or} \quad t = \frac{5}{4}$$

Disregard the negative solution. The paintbrush lands after  $\frac{5}{4}$  seconds.

$$47. h = -16t^2 + 100$$

$$0 = -((4t)^2 - 10^2)$$

$$0 = -(4t + 10)(4t - 10)$$

$$4t + 10 = 0 \quad \text{or} \quad 4t - 10 = 0$$

$$t = -\frac{5}{2} \quad \text{or} \quad t = \frac{5}{2}$$

Disregard the negative solution. The hickory nut lands after  $\frac{5}{2}$  seconds.

$$48. \text{ a. } h = -16t^2 + 8t$$

$$\text{ b. } 1 = -16t^2 + 8t$$

$$0 = -16t^2 + 8t - 1$$

$$0 = -((4t)^2 - 8t + 1^2)$$

$$0 = -((4t)^2 - 2(4t \cdot 1) + 1^2)$$

$$0 = -(4t - 1)^2$$

$$4t - 1 = 0$$

$$t = \frac{1}{4}$$

The grasshopper is 1 foot off the ground after  $\frac{1}{4}$  second.

$$49. h = -16t^2 + 56t + 5$$

$$54 = -16t^2 + 56t + 5$$

$$0 = -16t^2 + 56t - 49$$

$$0 = -((4t)^2 - 2(4t \cdot 7) + 7^2)$$

$$0 = -(4t - 7)^2$$

$$4t - 7 = 0$$

$$t = \frac{7}{4}$$

The ball reaches a maximum height of 54 feet only once, 1.75 seconds after it is thrown.

$$50. \text{ a. } y = -\frac{1}{4}x^2 + 3x$$

$x$	0	2	5	8	11
$y$	0	5	8.75	8	2.75

b. The equation makes sense for values of  $x \leq 12$ .

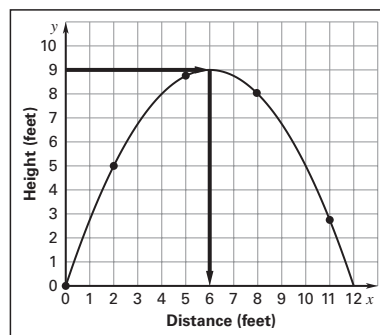
For  $x > 12$ ,  $y$  is negative.

c. Plotting the points in the table in part (a) and sketching a curve through the points, you can estimate that the arch reaches a height of 9 feet at about 6 feet from the left end.

$$\text{Check: } y = -\frac{1}{4}x^2 + 3x$$

$$y = -\frac{1}{4}(6)^2 + 3(6)$$

$$y = 9$$



$$51. \text{ a. } \text{Total area} = (2d)^2 = 4d^2$$

$$\text{Mirror area} = 3^2 = 9$$

$$\text{Stained glass area} = 4d^2 - 9$$

$$\text{ b. } 91 = 4d^2 - 9$$

$$0 = 4d^2 - 100$$

$$0 = (2d)^2 - 10^2$$

$$0 = (2d + 10)(2d - 10)$$

$$2d + 10 = 0 \quad \text{or} \quad 2d - 10 = 0$$

$$d = -5 \quad \text{or} \quad d = 5$$

Disregard the negative solution. The side length of the frame is  $2d = 10$  inches.

# Chapter 9, continued

52. a.

$n$	$n$ th odd integer	Sum of First $n$ odd integers	Sum as a power
1	1	1	$1^2$
2	3	$1 + 3 = 4$	$2^2$
3	5	$1 + 3 + 5 = 9$	$3^2$
4	7	$1 + 3 + 5 + 7 = 16$	$4^2$
5	9	$1 + 3 + 5 + 7 + 9 = 25$	$5^2$

- b. The sum of the first  $n$  odd integers is  $n^2$ . The sum of the first 10 integers is  $10^2 = 100$ .
- c. 11 is the 6<sup>th</sup> odd integer and 21 is the 11<sup>th</sup> odd integer. So, find the sum of the first 11 odd integers and subtract the sum of the first 5 odd integers.
- $$11^2 - 5^2 = 121 - 25 = 96$$
- d. The number of chairs in the first row, 15, is the 8<sup>th</sup> odd integer, and the number of chairs in the last row is the  $n$ th odd integer.

$$\begin{array}{r} \text{Total number} \\ \text{of chairs} \end{array} = \begin{array}{r} \text{Sum of first} \\ n \text{ odd integers} \end{array} - \begin{array}{r} \text{Sum of first} \\ 7 \text{ odd integers} \end{array}$$

$$120 = n^2 - 7^2$$

$$0 = n^2 - 169$$

$$0 = n^2 - 13^2$$

$$0 = (n + 13)(n - 13)$$

$$n + 13 = 0 \quad \text{or} \quad n - 13 = 0$$

$$n = -13 \quad \text{or} \quad n = 13$$

You will need  $13 - 7 = 6$  rows of chairs.

## Mixed Review

53.  $a + 6 = 3$

$$a = -3$$

55.  $8m + 4 = 20$

$$8m = 16$$

$$m = 2$$

57.  $(x - 9)(x + 1) = 0$

$$x - 9 = 0 \quad \text{or} \quad x + 1 = 0$$

$$x = 9 \quad \text{or} \quad x = -1$$

58.  $x^2 + 17x = -66$

$$x^2 + 17x + 66 = 0$$

$$(x + 11)(x + 6) = 0$$

$$x + 11 = 0 \quad \text{or} \quad x + 6 = 0$$

$$x = -11 \quad \text{or} \quad x = -6$$

59.  $x^2 = -12x + 45$

$$x^2 + 12x - 45 = 0$$

$$(x + 15)(x - 3) = 0$$

$$x + 15 = 0 \quad \text{or} \quad x - 3 = 0$$

$$x = -15 \quad \text{or} \quad x = 3$$

60.  $2y^2 + y = 15$

$$2y^2 + y - 15 = 0$$

$$(2y - 5)(y + 3) = 0$$

$$2y - 5 = 0 \quad \text{or} \quad y + 3 = 0$$

$$y = \frac{5}{2} \quad \text{or} \quad y = -3$$

61.  $22z - 35 = 3z^2$

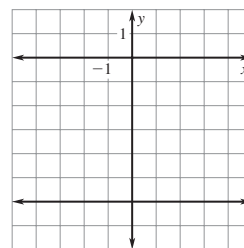
$$3z^2 - 22z + 35 = 0$$

$$(3z - 7)(z - 5) = 0$$

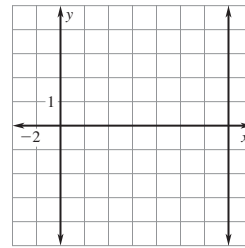
$$3z - 7 = 0 \quad \text{or} \quad z - 5 = 0$$

$$z = \frac{7}{3} \quad \text{or} \quad z = 5$$

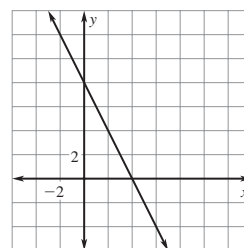
62.  $y = -6$



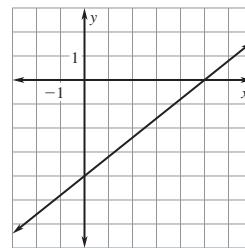
63.  $x = 14$



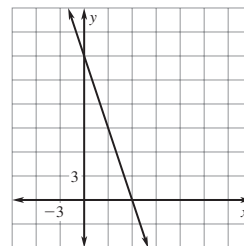
64.  $2x + y = 8$



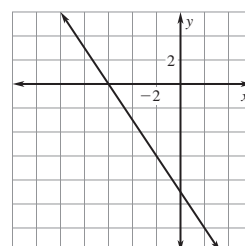
65.  $-4x + 5y = -20$



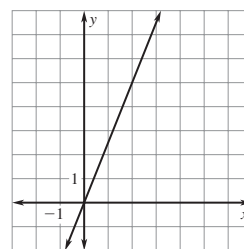
66.  $0.6x + 0.2y = 3.6$



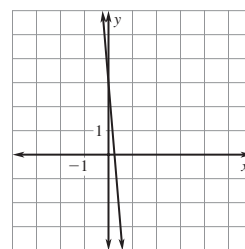
67.  $y = \frac{-3x}{2} - 9$



68.  $y = \frac{5}{2}x$

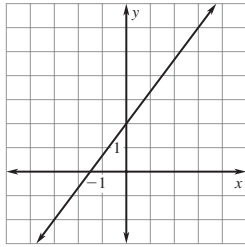


69.  $y = -12x + 3$



## Chapter 9, continued

70.  $y = \frac{4}{3}x + 2$



71.  $(2a - 3)(5a - 2) = 10a^2 - 4a - 15a + 6$   
 $= 10a^2 - 19a + 6$

72.  $(2x^2 + x + 3)(x - 1)$   
 $= 2x^2(x - 1) + x(x - 1) + 3(x - 1)$   
 $= 2x^3 - 2x^2 + x^2 - x + 3x - 3 = 2x^3 - x^2 + 2x - 3$

73.  $(c + 3)(c + 5) = c^2 + 5c + 3c + 15 = c^2 + 8c + 15$

74.  $(3x - 4)(2x - 7) = 6x^2 - 21x - 8x + 28$   
 $= 6x^2 - 29x + 28$

75.  $(2k - 11)(2k + 11) = (2k)^2 - 11^2 = 4k^2 - 121$

76.  $(y - 7)^2 = y^2 - 2(y \cdot 7) + 7^2 = y^2 - 14y + 49$

### 9.8 Guided Practice (pp. 607–609)

- $x(x - 2) + (x - 2) = (x - 2)(x + 1)$
- $a^3 + 3a^2 + a + 3 = (a^3 + 3a^2) + (a + 3)$   
 $= a^2(a + 3) + (a + 3)$   
 $= (a + 3)(a^2 + 1)$
- $y^2 + 2x + yx + 2y = (y^2 + 2y) + (yx + 2x)$   
 $= y(y + 2) + x(y + 2)$   
 $= (y + 2)(y + x)$
- $3x^3 - 12x = 3x(x^2 - 4) = 3x(x + 2)(x - 2)$
- $2y^3 - 12y^2 + 18y = 2y(y^2 - 6y + 9)$   
 $= 2y(y^2 - 2(y \cdot 3) + 3^2)$   
 $= 2y(y - 3)^2$
- $m^3 - 2m^2 - 8m = m(m^2 - 2m - 8) = m(m - 4)(m + 2)$
- $w^3 - 8w^2 + 16w = 0$   
 $w(w^2 - 8w + 16) = 0$   
 $w(w^2 - 2(w \cdot 4) + 4^2) = 0$   
 $w(w - 4)^2 = 0$   
 $w = 0$  or  $w - 4 = 0$   
 $w = 0$  or  $w = 4$
- $x^3 - 25x = 0$   
 $x(x^2 - 25) = 0$   
 $x(x + 5)(x - 5) = 0$   
 $x = 0$  or  $x + 5 = 0$  or  $x - 5 = 0$   
 $x = 0$  or  $x = -5$  or  $x = 5$
- $c^3 - 7c^2 + 12c = 0$   
 $c(c^2 - 7c + 12) = 0$   
 $c(c - 4)(c - 3) = 0$   
 $c = 0$  or  $c - 4 = 0$  or  $c - 3 = 0$   
 $c = 0$  or  $c = 4$  or  $c = 3$

10. Volume = Length • Width • Height  
(cubic feet) = (feet) • (feet) • (feet)

$$72 = x \cdot (x - 1) \cdot (x + 9)$$

$$72 = x(x - 1)(x + 9)$$

$$72 = x(x^2 + 8x - 9)$$

$$72 = x^3 + 8x^2 - 9x$$

$$0 = x^3 + 8x^2 + 9x - 72$$

$$0 = x^2(x + 8) - 9(x + 8)$$

$$0 = (x + 8)(x^2 - 9)$$

$$0 = (x + 8)(x + 3)(x - 3)$$

$$x + 8 = 0 \quad \text{or} \quad x + 3 = 0 \quad \text{or} \quad x - 3 = 0$$

$$x = -8 \quad \text{or} \quad x = -3 \quad \text{or} \quad x = 3$$

The length cannot be negative, so 3 is the correct value of  $x$ . The dimensions of the box are 3 feet long,  $3 - 1 = 2$  feet wide, and  $3 + 9 = 12$  feet high.

### 9.8 Exercises (pp. 610–613)

#### Skill Practice

- A polynomial is factored completely if it is written as a product of unfactorable polynomials with integer coefficients.
- A polynomial is unfactorable if it cannot be written as the product of polynomials with integer coefficients.
- $x(x - 8) + (x - 8) = (x - 8)(x + 1)$
- $5y(y + 3) - 2(y + 3) = (y + 3)(5y - 2)$
- $6z(z - 4) - 7(z - 4) = (z - 4)(6z - 7)$
- $10(a - 6) - 3a(a - 6) = (a - 6)(10 - 3a)$
- $b^2(b + 5) - 3(b + 5) = (b + 5)(b^2 - 3)$
- $7c^2(c + 9) + 2(c + 9) = (c + 9)(7c^2 + 2)$
- $x(13 + x) - (x + 13) = (x + 13)(x - 1)$
- $y^2(y - 4) + 5(4 - y) = y^2(y - 4) - 5(-4 + y)$   
 $= (y - 4)(y^2 - 5)$
- $12(z - 1) - 5z^2(1 - z) = 12(z - 1) + 5z^2(-1 + z)$   
 $= (z - 1)(12 + 5z^2)$
- $C; x^2(x - 8) + 5(8 - x) = x^2(x - 8) - 5(-8 + x)$   
 $= (x - 8)(x^2 - 5)$
- $x^3 + x^2 + 2x + 2 = x^2(x + 1) + 2(x + 1)$   
 $= (x + 1)(x^2 + 2)$
- $y^3 - 9y^2 + y - 9 = y^2(y - 9) + (y - 9)$   
 $= (y - 9)(y^2 + 1)$
- $z^3 - 4z^2 + 3z - 12 = z^2(z - 4) + 3(z - 4)$   
 $= (z - 4)(z^2 + 3)$
- $c^3 + 7c^2 + 5c + 35 = c^2(c + 7) + 5(c + 7)$   
 $= (c + 7)(c^2 + 5)$
- $a^3 + 13a^2 - 5a - 65 = a^2(a + 13) - 5(a + 13)$   
 $= (a + 13)(a^2 - 5)$
- $2s^3 - 3s^2 + 18s - 27 = s^2(2s - 3) + 9(2s - 3)$   
 $= (2s - 3)(s^2 + 9)$

## Chapter 9, continued

19.  $5n^3 - 4n^2 + 25n - 20 = n^2(5n - 4) + 5(5n - 4)$   
 $= (5n - 4)(n^2 + 5)$
20.  $x^2 + 8x - xy - 8y = x(x + 8) - y(x + 8)$   
 $= (x + 8)(x - y)$
21.  $y^2 + y + 5xy + 5x = y(y + 1) + 5x(y + 1)$   
 $= (y + 1)(y + 5x)$
22. The error occurred when the negative signs were forgotten.  
 $a^3 + 8a^2 - 6a - 48 = a^2(a + 8) - 6(a + 8)$   
 $= (a + 8)(a^2 - 6)$
23.  $x^4 - x^2 = x^2(x^2 - 1) = x^2(x + 1)(x - 1)$
24.  $36a^4 - 4a^2 = 4a^2(9a^2 - 1) = 4a((3a)^2 - 1)$   
 $= 4a(3a + 1)(3a - 1)$
25.  $3n^5 - 48n^3 = 3n^3(n^2 - 16) = 3n^3(n + 4)(n - 4)$
26.  $4y^6 - 16y^4 = 4y^4(y^2 - 4) = 4y^4(y + 2)(y - 2)$
27.  $75c^9 - 3c^7 = 3c^7(25c^2 - 1) = 3c^7(5c + 1)(5c - 1)$
28.  $72p - 2p^3 = 2p(36 - p^2) = 2p(6 + p)(6 - p)$
29.  $32s^4 - 8s^2 = 8s^2(4s^2 - 1) = 8s^2(2s + 1)(2s - 1)$
30.  $80z^8 - 45z^6 = 5z^6(16z^2 - 9) = 5z^6(4z + 3)(4z - 3)$
31.  $m^2 - 5m - 35$  Cannot be factored.
32.  $6g^3 - 24g^2 + 24g = 6g(g^2 - 4g + 4)$   
 $= 6g(g^2 - 2(g \cdot 2) + 2^2)$   
 $= 6g(g - 2)^2$
33.  $3w^4 + 24w^3 + 48w^2 = 3w^2(w^2 + 8w + 16)$   
 $= 3w^2(w^2 + 2(w \cdot 4) + 4^2)$   
 $= 3w^2(w + 4)^2$
34.  $3r^5 + 3r^4 - 90r^3 = 3r^3(r^2 + r - 30)$   
 $= 3r^3(r + 6)(r - 5)$
35.  $b^3 - 5b^2 - 4b + 20 = b^2(b - 5) - 4(b - 5)$   
 $= (b - 5)(b^2 - 4)$   
 $= (b - 5)(b + 2)(b - 2)$
36.  $h^3 + 4h^2 - 25h - 100 = h^2(h + 4) - 25(h + 4)$   
 $= (h + 4)(h^2 - 25)$   
 $= (h + 4)(h + 5)(h - 5)$
37.  $9t^3 + 18t - t^2 - 2 = t^2(9t - 1) + 2(9t - 1)$   
 $= (9t - 1)(t^2 + 2)$
38.  $2x^5y - 162x^3y = 2x^3y(x^2 - 81) = 2x^3y(x + 9)(x - 9)$
39.  $7a^3b^3 - 63ab^3 = 7ab^3(a^2 - 9) = 7ab^3(a + 3)(a - 3)$
40.  $-4s^3t^3 + 24s^2t^2 - 36st = -4st(s^2t^2 - 6st + 9)$   
 $= -4st((st)^2 - 2(st \cdot 3) + 3^2)$   
 $= -4st(st - 3)^2$
41. D;  $3x^6 - 75x^4 = 3x^4(x^2 - 25) = 3x^4(x - 5)(x + 5)$
42. The polynomial was not factored completely.  
 The factor  $x^2 - 9$  is the difference of two squares.  
 $x^3 - 6x^2 - 9x + 54 = x^2(x - 6) - 9(x - 6)$   
 $= (x - 6)(x^2 - 9)$   
 $= (x + 6)(x + 3)(x - 3)$
43.  $x^3 + x^2 - 4x - 4 = 0$   
 $x^2(x + 1) - 4(x + 1) = 0$   
 $(x + 1)(x^2 - 4) = 0$   
 $(x + 1)(x + 2)(x - 2) = 0$   
 $x + 1 = 0$  or  $x + 2 = 0$  or  $x - 2 = 0$   
 $x = -1$  or  $x = -2$  or  $x = 2$
44.  $a^3 - 11a^2 - 9a + 99 = 0$   
 $a^2(a - 11) - 9(a - 11) = 0$   
 $(a - 11)(a^2 - 9) = 0$   
 $(a - 11)(a + 3)(a - 3) = 0$   
 $a - 11 = 0$  or  $a + 3 = 0$  or  $a - 3 = 0$   
 $a = 11$  or  $a = -3$  or  $a = 3$
45.  $4y^3 - 7y^2 - 16y + 28 = 0$   
 $y^2(4y - 7) - 4(4y - 7) = 0$   
 $(4y - 7)(y^2 - 4) = 0$   
 $(4y - 7)(y + 2)(y - 2) = 0$   
 $4y - 7 = 0$  or  $y + 2 = 0$  or  $y - 2 = 0$   
 $y = \frac{7}{4}$  or  $y = -2$  or  $y = 2$
46.  $5n^3 - 30n^2 + 40n = 0$   
 $5n(n^2 - 6n + 8) = 0$   
 $5n(n - 2)(n - 4) = 0$   
 $5n = 0$  or  $n - 2 = 0$  or  $n - 4 = 0$   
 $n = 0$  or  $n = 2$  or  $n = 4$
47.  $3b^3 + 24b^2 + 45b = 0$   
 $3b(b^2 + 8b + 15) = 0$   
 $3b(b + 5)(b + 3) = 0$   
 $3b = 0$  or  $b + 5 = 0$  or  $b + 3 = 0$   
 $b = 0$  or  $b = -5$  or  $b = -3$
48.  $2t^5 + 2t^4 - 144t^3 = 0$   
 $2t^3(t^2 + t - 72) = 0$   
 $2t^3(t + 9)(t - 8) = 0$   
 $2t^3 = 0$  or  $t + 9 = 0$  or  $t - 8 = 0$   
 $t = 0$  or  $t = -9$  or  $t = 8$
49.  $z^3 - 81z = 0$   
 $z(z^2 - 81) = 0$   
 $z(z + 9)(z - 9) = 0$   
 $z = 0$  or  $z + 9 = 0$  or  $z - 9 = 0$   
 $z = 0$  or  $z = -9$  or  $z = 9$
50.  $c^4 - 100c^2 = 0$   
 $c^2(c^2 - 100) = 0$   
 $c^2(c + 10)(c - 10) = 0$   
 $c^2 = 0$  or  $c + 10 = 0$  or  $c - 10 = 0$   
 $c = 0$  or  $c = -10$  or  $c = 10$

## Chapter 9, continued

51.  $12s - 3s^3 = 0$   
 $3s(4 - s^2) = 0$   
 $3s(2 + s)(2 - s) = 0$   
 $3s = 0$  or  $2 + s = 0$  or  $2 - s = 0$   
 $s = 0$  or  $s = -2$  or  $s = 2$
52.  $2x^3 - 10x^2 + 40 = 8x$   
 $2x^3 - 10x^2 - 8x + 40 = 0$   
 $2x^2(x - 5) - 8(x - 5) = 0$   
 $(x - 5)(2x^2 - 8) = 0$   
 $2(x - 5)(x^2 - 4) = 0$   
 $2(x - 5)(x + 2)(x - 2) = 0$   
 $x - 5 = 0$  or  $x + 2 = 0$  or  $x - 2 = 0$   
 $x = 5$  or  $x = -2$  or  $x = 2$
53.  $3p + 1 = p^2 + 3p^3$   
 $3p^3 + p^2 - 3p - 1 = 0$   
 $p^2(3p + 1) - (3p + 1) = 0$   
 $(3p + 1)(p^2 - 1) = 0$   
 $(3p + 1)(p - 1)(p + 1) = 0$   
 $3p + 1 = 0$  or  $p + 1 = 0$  or  $p - 1 = 0$   
 $p = -\frac{1}{3}$  or  $p = -1$  or  $p = 1$
54.  $m^3 - 3m^2 = 4m - 12$   
 $m^3 - 3m^2 - 4m + 12 = 0$   
 $m^2(m - 3) - 4(m - 3) = 0$   
 $(m - 3)(m^2 - 4) = 0$   
 $(m - 3)(m + 2)(m - 2) = 0$   
 $m - 3 = 0$  or  $m - 2 = 0$  or  $m + 2 = 0$   
 $m = 3$  or  $m = 2$  or  $m = -2$
55. No. When the polynomial is factored completely, the equation becomes  $(x + 2)(x^2 + 3) = 0$ . The factor  $x^2 + 3$  yields no real solutions when it is set equal to zero. So, the only real solution of the equation is  $x = -2$ .  
 $x^3 + 2x^2 + 3x + 6 = 0$   
 $x^2(x + 2) + 3(x + 2) = 0$   
 $(x + 2)(x^2 + 3) = 0$   
 $x + 2 = 0$  or  $x^2 + 3 = 0 \leftarrow$  No real solution  
 $x = -2$
56.  $(x + 4)(x - 1)(x) = 12$   
 $(x^2 + 3x - 4)x = 12$   
 $x^3 + 3x^2 - 4x - 12 = 0$   
 $x^2(x + 3) - 4(x + 3) = 0$   
 $(x + 3)(x^2 - 4) = 0$   
 $(x + 3)(x + 2)(x - 2) = 0$   
 $x + 3 = 0$  or  $x + 2 = 0$  or  $x - 2 = 0$   
 $x = -3$  or  $x = -2$  or  $x = 2$

$x = 2$  The length is 6 inches,  
 $x + 4 = 6$  the width is 1 inch, and  
 $x - 1 = 1$  the height is 2 inches.

57.  $(x + 8)(x)(x - 2) = 96$   
 $(x^2 + 6x - 16)x = 96$   
 $x^3 + 6x^2 - 16x - 96 = 0$   
 $x^2(x + 6) - 16(x + 6) = 0$   
 $(x + 6)(x^2 - 16) = 0$   
 $(x + 6)(x + 4)(x - 4) = 0$   
 $x + 6 = 0$  or  $x + 4 = 0$  or  $x - 4 = 0$   
 $x = -6$  or  $x = -4$  or  $x = 4$   
 $x = 4$  The length is 12 feet,  
 $x + 8 = 12$  the width is 4 feet, and  
 $x - 2 = 2$  the height is 2 feet.
58.  $x^3 + 2x^2y - x - 2y = x^2(x + 2y) - (x + 2y)$   
 $= (x + 2y)(x^2 - 1)$   
 $= (x + 2y)(x + 1)(x - 1)$
59.  $8b^3 - 4b^2a - 18b + 9a = 4b^2(2b - a) - 9(2b - a)$   
 $= (2b - a)(4b^2 - 9)$   
 $= (2b - a)(2b + 3)(2b - 3)$
60.  $4s^2 - s + 12st - 3t = s(4s - 1) + 3t(4s - 1)$   
 $= (4s - 1)(s + 3t)$
61.  $6x^2 + 5x - 4$   
 $6(-4) = -24$   
 $-24 = 8(-3)$  and  $8 - 3 = 5$   
 $6x^2 + 5x - 4 = 6x^2 + 8x - 3x - 4$   
 $= 2x(3x + 4) - (3x + 4)$   
 $= (3x + 4)(2x - 1)$
62.  $10s^2 + 19s + 6$   
 $10(6) = 60$   
 $60 = 15(4)$  and  $15 + 4 = 19$   
 $10s^2 + 19s + 6 = 10s^2 + 15s + 4s + 6$   
 $= 5s(2s + 3) + 2(2s + 3)$   
 $= (2s + 3)(5s + 2)$
63.  $12n^2 - 13n + 3$   
 $12(3) = 36$   
 $36 = -9(-4)$  and  $-9 - 4 = -13$   
 $12n^2 - 13n + 3 = 12n^2 - 9n - 4n + 3$   
 $= 3n(4n - 3) - (4n - 3)$   
 $= (4n - 3)(3n - 1)$
64.  $16a^2 + 14a + 3$   
 $16(3) = 48$   
 $48 = 8(6)$  and  $8 + 6 = 14$   
 $16a^2 + 14a + 3 = 16a^2 + 8a + 6a + 3$   
 $= 8a(2a + 1) + 3(2a + 1)$   
 $= (2a + 1)(8a + 3)$

## Chapter 9, continued

65.  $21w^2 + 8w - 4$   
 $21(-4) = -84$   
 $-84 = 14(-6)$  and  $14 - 6 = 8$   
 $21w^2 + 8w - 4 = 21w^2 + 14w - 6w - 4$   
 $= 7w(3w + 2) - 2(3w + 2)$   
 $= (3w + 2)(7w - 2)$

66.  $15y^2 - 31y + 10$   
 $15(10) = 150$   
 $150 = -25(-6)$  and  $-25 - 6 = -31$   
 $15y^2 - 31y + 10 = 15y^2 - 25y - 6y + 10$   
 $= 5y(3y - 5) - 2(3y - 5)$   
 $= (3y - 5)(5y - 2)$

67. Rewrite the middle term as  $ab + ab$  and group the terms.  
 $a^2 + 2ab + b^2 = a^2 + ab + ab + b^2$  Rewrite  $2ab$  as  $ab + ab$ .  
 $= (a^2 + ab) + (ab + b^2)$  Group terms.  
 $= a(a + b) + b(a + b)$  Factor each group.  
 $= (a + b)(a + b)$  Distributive property.  
 $= (a + b)^2$  Simplify.

### Problem Solving

68. Volume =  $\pi \cdot$  Radius<sup>2</sup> • Height  
(cubic inches) =  $\pi \cdot$  (square inches) • (inches)  
 $24\pi = \pi \cdot r^2 \cdot 6$   
 $24\pi = 6\pi r^2$   
 $0 = 6\pi r^2 - 24\pi$   
 $0 = 6\pi(r^2 - 4)$   
 $0 = 6\pi(r + 2)(r - 2)$   
 $r + 2 = 0$  or  $r - 2 = 0$   
 $r = -2$  or  $r = 2$

The radius cannot be negative, so the radius is 2 inches.

69. a. Volume = Length • Width • Height  
(cubic inches) = (inches) • (inches) • (inches)  
 $= 4 \cdot w \cdot (w + 4)$

A polynomial that represents the volume of the birdhouse is  $4w^2 + 16w$ .

b.  $128 = 4w(w + 4)$   
 $0 = 4w^2 + 16w - 128$   
 $0 = 4(w^2 + 4w - 32)$   
 $0 = 4(w + 8)(w - 4)$   
 $w + 8 = 0$  or  $w - 4 = 0$   
 $w = -8$  or  $w = 4$

The width must be positive, so  $w = -8$  can be discarded.

$w = 4$   
 $w + 4 = 8$

The dimensions of the birdhouse are 4 inches long by 4 inches wide by 8 inches high.

70. Volume = Length • Width • Height  
(cubic inches) = (inches) • (inches) • (inches)

$1152 = (2w + 4)(w)(18 - w)$   
 $0 = -2w^3 + 32w^2 + 72w - 1152$   
 $0 = -2w^2(w - 16) + 72(w - 16)$   
 $0 = (w - 16)(72 - 2w^2)$   
 $w - 16 = 0$  or  $72 - 2w^2 = 0$   
 $w = 16$  or  $w = 6$

When  $w = 16$ :  
Height  $\stackrel{?}{>}$  Width  
 $18 - w \stackrel{?}{>} w$   
 $18 - 16 \not> 16$

When  $w = 6$ :  
Height  $\stackrel{?}{>}$  Width  
 $18 - w \stackrel{?}{>} w$   
 $18 - 6 > 6$  ✓

The solution  $w = 6$  gives a height that is greater than the width, so 6 is the correct value of  $w$ .

Length =  $2w + 4 = 16$

Width =  $w = 6$

Height =  $18 - w = 12$

The dimensions of the gift bag are 16 inches long by 6 inches wide by 12 inches high.

71. a.  $h = -4.9t^2 + 3.9t + 1$   
 $0 = -4.9t^2 + 3.9t + 1$   
 $0 = -(4.9t^2 - 3.9t - 1)$   
 $0 = -(4.9t + 1)(t - 1)$   
 $4.9t + 1 = 0$  or  $t - 1 = 0$   
 $t \approx -0.2$  or  $t = 1$

The zeros are 1 and approximately  $-0.2$ .

b. The zeros are the times when  $h = 0$ , or when the ball touches the ground. A negative time does not make sense in this situation, so  $t \approx -0.2$  can be discarded. The pallino will land 1 second after being thrown.

72. a. Let  $y = 22.5$ .  
 $y = -10x^2 + 30x$   
 $22.5 = -10x^2 + 30x$   
 $0 = (-10x^2 + 30x - 22.5)(10)$   
 $0 = -100x^2 + 300x - 225$   
 $0 = -25(4x^2 - 12x + 9)$   
 $0 = -25(2x - 3)^2$   
 $2x - 3 = 0$   
 $x = \frac{3}{2} = 1.5$

When the robot's height is 22.5 feet, its horizontal distance from its starting point is 1.5 feet.

# Chapter 9, continued

- b. The robot will be on the ground when the vertical distance ( $y$ ) is zero.

$$y = -10x^2 + 30x$$

$$0 = -10x^2 + 30x$$

$$0 = -10x(x - 3)$$

$$-10x = 0 \quad \text{or} \quad x - 3 = 0$$

$$x = 0 \quad \text{or} \quad x = 3$$

The robot's starting position is the origin, so  $x = 0$  can be discarded. When the robot lands, it will have traveled 3 feet horizontally.

73. a. Volume = (cubic inches) = (length in inches) • (width in inches) • (height in inches)

$$V = (9 - h) \cdot (4 + h) \cdot h$$

$$V = -h^3 + 5h^2 + 36h$$

- b.  $180 = -h^3 + 5h^2 + 36h$

$$0 = -h^3 + 5h^2 + 36h - 180$$

$$0 = -h^2(h - 5) + 36(h - 5)$$

$$0 = -(h - 5)(h^2 - 36)$$

$$0 = -(h - 5)(h + 6)(h - 6)$$

$$h - 5 = 0 \quad \text{or} \quad h + 6 = 0 \quad \text{or} \quad h - 6 = 0$$

$$h = 5 \quad \text{or} \quad h = -6 \quad \text{or} \quad h = 6$$

The height cannot be negative, so  $h = -6$  can be discarded. Possible dimensions:

$$h = 5; \text{ height} = 5 \text{ inches}$$

$$9 - h = 4; \text{ length} = 4 \text{ inches}$$

$$4 + h = 9; \text{ width} = 9 \text{ inches}$$

$$h = 6; \text{ height} = 6 \text{ inches}$$

$$9 - h = 3; \text{ length} = 3 \text{ inches}$$

$$4 + h = 10; \text{ width} = 10 \text{ inches}$$

c.

$$\begin{array}{l} \text{Surface area} = 2 \cdot (\text{in.}) \cdot (\text{in.}) + 2 \cdot (\text{in.}) \cdot (\text{in.}) + 2 \cdot (\text{in.}) \cdot (\text{in.}) \\ \text{(Square inches)} \end{array}$$

$$+ 2 \cdot (\text{in.}) \cdot (\text{in.})$$

Possible box 1:

$$SA = 2(4 \cdot 9) + 2(4 \cdot 5) + 2(5 \cdot 9)$$

$$= 72 + 40 + 90$$

$$= 202$$

Possible box 2:

$$SA = 2(3 \cdot 10) + 2(3 \cdot 6) + 2(6 \cdot 10)$$

$$= 60 + 36 + 120$$

$$= 216$$

Box 1 has a surface area of 202 square inches; Box 2 has a surface area of 216 square inches. So, the box with the smallest possible surface area should have the dimensions of box 1: height = 5 inches; length = 4 inches; width = 9 inches.

74. a. The surface area of a cube is six times the area of one face of the cube. The area of one face of the cube is  $s^2$  where  $s$  = the side length.

$$A = 6s^2$$

$$54 = 6s^2$$

$$0 = 6s^2 - 54$$

$$0 = 6(s^2 - 9)$$

$$0 = 6(s + 3)(s - 3)$$

$$s + 3 = 0 \quad \text{or} \quad s - 3 = 0$$

$$s = -3 \quad \text{or} \quad s = 3$$

The side length of a cube cannot be negative, so  $s = 3$  inches.

- b. Volume of a cube =  $s^3$

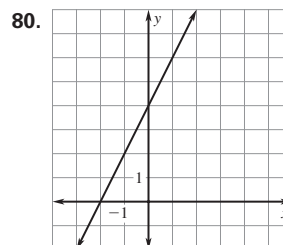
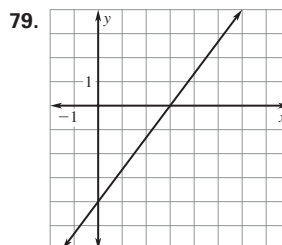
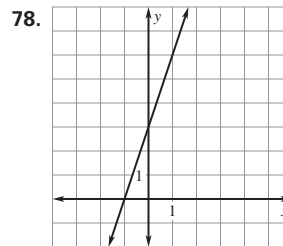
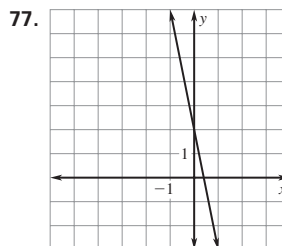
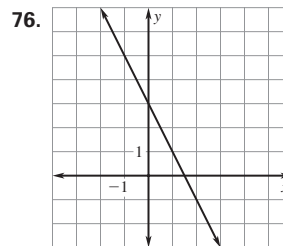
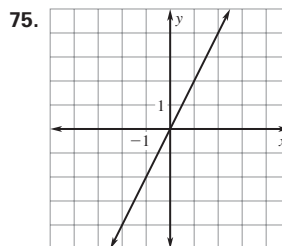
When  $s = 3$ :

$$V = 3^3$$

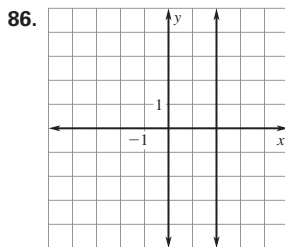
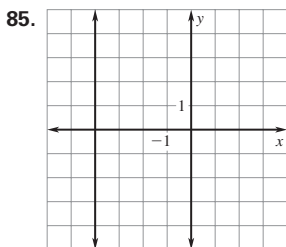
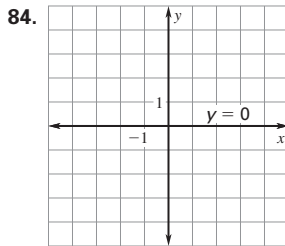
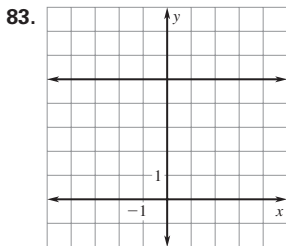
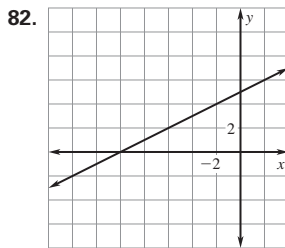
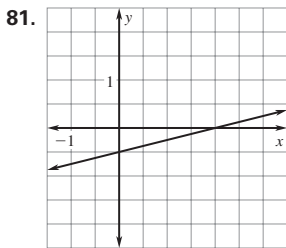
$$V = 27$$

The greatest possible volume is 27 cubic inches. The actual volume inside the cube may be less, depending on the thickness of the plastic. The thickness would cause the inside side length to be less than 3, so when this length is cubed to find the volume, it would be less than 27.

## Mixed Review



# Chapter 9, continued



87. Using the points (1, 2) and (0, 0):  $m = \frac{2-0}{1-0} = 2$

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

$$y - 0 = 2(x - 0)$$

$$y = 2x$$

The equation of the line is  $y = 2x$ .

88. Using the points (3, 5) and (0, 0):  $m = \frac{5-0}{3-0} = \frac{5}{3}$

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

$$y - 0 = \frac{5}{3}(x - 0)$$

$$y = \frac{5}{3}x$$

The equation of the line is  $y = \frac{5}{3}x$ .

89. Using the points (4, 5) and (-1, 0):

$$m = \frac{5-0}{4-(-1)} = \frac{5}{5} = 1$$

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

$$y - 5 = 1(x - 4)$$

$$y - 5 = x - 4$$

$$y = x + 1$$

The equation of the line is  $y = x + 1$ .

### Quiz 9.7-9.8 (p. 613)

1.  $x^2 - 400 = x^2 - 20^2 = (x + 20)(x - 20)$

2.  $18 - 32z^2 = 2(9 - 16z^2)$   
 $= 2[3^2 - (4z)^2]$   
 $= 2(3 + 4z)(3 - 4z)$

3.  $169x^2 - 25y^2 = (13x)^2 - (5y)^2 = (13x + 5y)(13x - 5y)$

4.  $n^2 - 6n + 9 = n^2 - 2(n \cdot 3) + 3^2 = (n - 3)^2$

5.  $100a^2 + 20a + 1 = (10a)^2 + 2(10a \cdot 1) + 1^2$   
 $= (10a + 1)^2$

6.  $8r^2 - 40rs + 50s^2 = 2(4r^2 - 20rs + 25s^2)$   
 $= 2((2r)^2 - 2(2r \cdot 5s) + (5s)^2)$   
 $= 2(2r - 5s)^2$

7.  $3x^5 - 75x^3 = 3x^3(x^2 - 25) = 3x^3(x + 5)(x - 5)$

8.  $72s^4 - 8s^2 = 8s^2(9s^2 - 1) = 8s^2(3s + 1)(3s - 1)$

9.  $3x^4y - 300x^2y = 3x^2y(x^2 - 100)$   
 $= 3x^2y(x + 10)(x - 10)$

10.  $a^3 - 4a^2 - 21a = a(a^2 - 4a - 21) = a(a - 7)(a + 3)$

11.  $2h^4 + 28h^3 + 98h^2 = 2h^2(h^2 + 14h + 49)$   
 $= 2h^2(h^2 + 2(h \cdot 7) + 7^2)$   
 $= 2h^2(h + 7)^2$

12.  $z^3 - 4z^2 - 16z + 64 = z^2(z - 4) - 16(z - 4)$   
 $= (z - 4)(z^2 - 16)$   
 $= (z - 4)(z - 4)(z + 4)$   
 $= (z - 4)^2(z + 4)$

13.  $x^2 + 10x + 25 = 0$   
 $(x + 5)^2 = 0$   
 $x + 5 = 0$   
 $x = -5$

14.  $48 - 27m^3 = 0$   
 $3(16 - 9m^2) = 0$   
 $3(4 + 3m)(4 - 3m) = 0$   
 $4 + 3m = 0$  or  $4 - 3m = 0$   
 $m = -\frac{4}{3}$  or  $m = \frac{4}{3}$

15.  $w^3 - w^2 - 4w + 4 = 0$   
 $w^3 - 4w - w^2 + 4 = 0$   
 $w(w^2 - 4) - (w^2 - 4) = 0$   
 $(w^2 - 4)(w - 1) = 0$   
 $(w + 2)(w - 2)(w - 1) = 0$   
 $w + 2 = 0$  or  $w - 2 = 0$  or  $w - 1 = 0$   
 $w = -2$  or  $w = 2$  or  $w = 1$

16.  $4x^3 - 28x^2 + 40x = 0$   
 $4x(x^2 - 7x + 10) = 0$   
 $4x(x - 5)(x - 2) = 0$   
 $4x = 0$  or  $x - 5 = 0$  or  $x - 2 = 0$   
 $x = 0$  or  $x = 5$  or  $x = 2$

17.  $3x^5 - 6x^4 - 45x^3 = 0$   
 $3x^3(x^2 - 2x - 15) = 0$   
 $3x^3(x - 5)(x + 3) = 0$   
 $3x^3 = 0$  or  $x - 5 = 0$  or  $x + 3 = 0$   
 $x = 0$  or  $x = 5$  or  $x = -3$

## Chapter 9, continued

18.  $x^3 - 121x = 0$   
 $x(x^2 - 121) = 0$   
 $x(x + 11)(x - 11) = 0$   
 $x = 0$  or  $x + 11 = 0$  or  $x - 11 = 0$   
 $x = -11$  or  $x = 11$

19. a. Volume of a cylinder =  $\pi r^2 h = 8\pi r^2$

b.  $72\pi = 8\pi r^2$   
 $0 = 8\pi r^2 - 72\pi$   
 $0 = 8\pi(r^2 - 9)$   
 $0 = 8\pi(r + 3)(r - 3)$   
 $r + 3 = 0$  or  $r - 3 = 0$   
 $r = -3$  or  $r = 3$

A geometric length must be positive, so  $r = -3$  can be discarded. The radius of the cylinder is 3 inches.

### Mixed Review of Problem Solving (p. 614)

1. a. Area = length  $\cdot$  width =  $(w + 5) \cdot w = w^2 + 5w$

b.  $150 = w^2 + 5w$   
 $0 = w^2 + 5w - 150$   
 $0 = (w + 15)(w - 10)$   
 $w + 15 = 0$  or  $w - 10 = 0$   
 $w = -15$  or  $w = 10$

The width cannot be negative, so  $w = -15$  can be discarded. So, the width is 10 feet and the length is  $10 + 5 = 15$  feet.

2. a. Volume = length  $\cdot$  width  $\cdot$  height

$= (x + 9)(x)(x - 4)$   
 $= x^3 + 5x^2 - 36x$

b.  $180 = x^3 + 5x^2 - 36x$   
 $0 = x^3 + 5x^2 - 36x - 180$   
 $0 = x^2(x + 5) - 36(x + 5)$   
 $0 = (x + 5)(x^2 - 36)$   
 $0 = (x + 5)(x + 6)(x - 6)$   
 $x + 5 = 0$  or  $x + 6 = 0$  or  $x - 6 = 0$   
 $x = -5$  or  $x = -6$  or  $x = 6$

Because  $x = 6$  is the only positive solution, the width is 6 inches, the length is  $6 + 9 = 15$  inches, and the height is  $6 - 4 = 2$  inches.

3. a. Area = length  $\cdot$  width =  $(x - 4)^2 = x^2 - 8x + 16$

b.  $100 = x^2 - 8x + 16$   
 $0 = x^2 - 8x - 84$   
 $0 = (x - 14)(x + 6)$   
 $x - 14 = 0$  or  $x + 6 = 0$   
 $x = 14$  or  $x = -6$

Length cannot be negative, so  $x = -6$  can be discarded. The side length of the original piece of wood was 14 inches. So, the original area was  $x^2 = 14^2 = 196$  square inches.

### 4. Sample answer:

A cannonball that is shot straight up from the ground at 48 feet per second can be modeled using the vertical motion model  $h = -16t^2 + 48t$ .

When  $h = 0$ :

$0 = -16t(t - 3)$   
 $-16t = 0$  or  $t - 3 = 0$   
 $t = 0$  or  $t = 3$

These  $t$ -values represent the times (in seconds) that the cannonball is at height 0 ft, or on the ground. Because  $t = 3$ , it takes 3 seconds for the ball to return to the ground.

5. a.  $h = -16t^2 + vt + s$

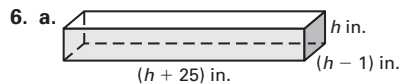
$h = -16t^2 + 80t + 3$

b.  $99 = -16t^2 + 80t + 3$

$0 = -16t^2 + 80t - 96$   
 $0 = -16(t^2 - 5t + 6)$   
 $0 = -16(t - 3)(t - 2)$   
 $t - 3 = 0$  or  $t - 2 = 0$   
 $t = 3$  or  $t = 2$

The ball reaches 99 feet after 2 seconds,

c. Yes, the ball reaches 99 feet twice, once at  $t = 2$  seconds and once at  $t = 3$  seconds.



b. Volume = length  $\cdot$  width  $\cdot$  height

$= (h + 25)(h - 1)(h)$   
 $= h^3 + 24h^2 - 25h$

c.  $600 = h^3 + 24h^2 - 25h$

$0 = h^3 + 24h^2 - 25h - 600$   
 $0 = h^2(h + 24) - 25(h + 24)$   
 $0 = (h + 24)(h^2 - 25)$   
 $0 = (h + 24)(h + 5)(h - 5)$   
 $h + 24 = 0$  or  $h + 5 = 0$  or  $h - 5 = 0$   
 $h = -24$  or  $h = -5$  or  $h = 5$

Because height cannot be negative, the height is 5 inches. The area of the top is the length  $(h + 25)$  times the width  $(h - 1)$ . So,  $A = 30 \cdot 4 = 120$  square inches.

7. No, the initial height of the ball is not given so there is not enough information given to solve for  $t$  when using the vertical motion model.



## Chapter 9, continued

28.  $2a^2 + 26a = 0$

$$2a(a + 13) = 0$$

$$2a = 0 \quad \text{or} \quad a + 13 = 0$$

$$a = 0 \quad \text{or} \quad a = -13$$

29.  $3t^2 - 33t = 0$

$$3t(t - 11) = 0$$

$$3t = 0 \quad \text{or} \quad t - 11 = 0$$

$$t = 0 \quad \text{or} \quad t = 11$$

30.  $8x^2 - 4x = 0$

$$4x(2x - 1) = 0$$

$$4x = 0 \quad \text{or} \quad 2x - 1 = 0$$

$$x = 0 \quad \text{or} \quad x = \frac{1}{2}$$

31.  $m^2 = 9m$

$$m^2 - 9m = 0$$

$$m(m - 9) = 0$$

$$m = 0 \quad \text{or} \quad m - 9 = 0$$

$$m = 9$$

32.  $5y^2 = -50y$

$$5y^2 + 50y = 0$$

$$5y(y + 10) = 0$$

$$5y = 0 \quad \text{or} \quad y + 10 = 0$$

$$y = 0 \quad \text{or} \quad y = -10$$

33.  $21h^2 = 7h$

$$21h^2 - 7h = 0$$

$$7h(3h - 1) = 0$$

$$7h = 0 \quad \text{or} \quad 3h - 1 = 0$$

$$h = 0 \quad \text{or} \quad h = \frac{1}{3}$$

34.  $n^2 + 15n + 26 = (n + 2)(n + 13)$

35.  $s^2 + 10s - 11 = (s - 1)(s + 11)$

36.  $b^2 - 5b - 14 = (b + 2)(b - 7)$

37.  $a^2 + 5a - 84 = (a - 7)(a + 12)$

38.  $t^2 - 24t + 135 = (t - 9)(t - 15)$

39.  $x^2 + 4x - 32 = (x - 4)(x + 8)$

40.  $p^2 + 9p + 14 = (p + 2)(p + 7)$

41.  $c^2 + 8c + 15 = (c + 3)(c + 5)$

42.  $y^2 - 10y + 21 = (y - 3)(y - 7)$

43.  $7x^2 - 8x = -1$

$$7x^2 - 8x + 1 = 0$$

$$(7x - 1)(x - 1) = 0$$

$$7x - 1 = 0 \quad \text{or} \quad x - 1 = 0$$

$$x = \frac{1}{7} \quad \text{or} \quad x = 1$$

44.  $4n^2 + 3 = 7n$

$$4n^2 - 7n + 3 = 0$$

$$(4n - 3)(n - 1) = 0$$

$$4n - 3 = 0 \quad \text{or} \quad n - 1 = 0$$

$$n = \frac{3}{4} \quad \text{or} \quad n = 1$$

45.  $3s^2 + 4s + 4 = 8$

$$3s^2 + 4s - 4 = 0$$

$$(3s - 2)(s + 2) = 0$$

$$3s - 2 = 0 \quad \text{or} \quad s + 2 = 0$$

$$s = \frac{2}{3} \quad \text{or} \quad s = -2$$

46.  $6z^2 + 13z = 5$

$$6z^2 + 13z - 5 = 0$$

$$(3z - 1)(2z + 5) = 0$$

$$3z - 1 = 0 \quad \text{or} \quad 2z + 5 = 0$$

$$z = \frac{1}{3} \quad \text{or} \quad z = -\frac{5}{2}$$

47.  $-4r^2 = 18r + 18$

$$0 = 4r^2 + 18r + 18$$

$$0 = 2(2r^2 + 9r + 9)$$

$$0 = 2(2r + 3)(r + 3)$$

$$2r + 3 = 0 \quad \text{or} \quad r + 3 = 0$$

$$r = -\frac{3}{2} \quad \text{or} \quad r = -3$$

48.  $9a^2 = 6a + 24$

$$9a^2 - 6a - 24 = 0$$

$$3(3a^2 - 2a - 8) = 0$$

$$3(3a + 4)(a - 2) = 0$$

$$3a + 4 = 0 \quad \text{or} \quad a - 2 = 0$$

$$a = -\frac{4}{3} \quad \text{or} \quad a = 2$$

49.  $h = -16t^2 + vt + s$

$$h = -16t^2 + 46t + 6$$

$$0 = -16t^2 + 46t + 6$$

$$0 = -2(8t^2 - 23t - 3)$$

$$0 = -2(8t + 1)(t - 3)$$

$$8t + 1 = 0 \quad \text{or} \quad t - 3 = 0$$

$$t = -\frac{1}{8} \quad \text{or} \quad t = 3$$

A negative solution does not make sense in this

situation, so disregard  $-\frac{1}{8}$ . The ball lands on the ground after 3 seconds.

50. Area = length • width

$$21 = (2w - 1)(w)$$

$$0 = 2w^2 - w - 21$$

$$0 = (2w - 7)(w + 3)$$

$$2w - 7 = 0 \quad \text{or} \quad w + 3 = 0$$

$$w = \frac{7}{2} \quad \text{or} \quad w = -3$$

The width cannot be negative, so disregard  $-3$ . The

length of the rectangle is  $2w - 1 = 2\left(\frac{7}{2}\right) - 1 = 6$  inches.

51.  $z^2 - 225 = z^2 - 15^2 = (z + 15)(z - 15)$

52.  $a^2 - 16y^2 = a^2 - (4y)^2 = (a + 4y)(a - 4y)$

## Chapter 9, continued

53.  $12 - 48n^2 = 12(1 - 4n^2)$   
 $= 12(1 - (2n)^2)$   
 $= 12(1 + 2n)(1 - 2n)$
54.  $x^2 + 20x + 100 = x^2 + 2(x \cdot 10) + 10^2 = (x + 10)^2$
55.  $16p^2 - 8p + 1 = (4p)^2 - 2(4p \cdot 1) + 1^2 = (4p - 1)^2$
56.  $-2y^2 + 32y - 128 = -2(y^2 - 16y + 64)$   
 $= -2(y^2 - 2(y \cdot 8) + 8^2)$   
 $= -2(y - 8)^2$
57.  $h = -16t^2 + vt + s$   
 $h = -16t^2 + 16$   
 $0 = -16t^2 + 16$   
 $0 = -16(t^2 - 1)$   
 $0 = -16(t + 1)(t - 1)$   
 $t + 1 = 0$  or  $t - 1 = 0$   
 $t = -1$  or  $t = 1$
- A negative answer does not make sense in this situation.  
 The penny lands after 1 second.
58.  $a^3 + 6a - 5a^2 - 30 = a(a^2 + 6) - 5(a^2 + 6)$   
 $= (a^2 + 6)(a - 5)$
59.  $y^2 + 3y + yx + 3x = y(y + 3) + x(y + 3)$   
 $= (y + 3)(y + x)$
60.  $x^3 - 11x^2 - x + 11 = x^2(x - 11) - (x - 11)$   
 $= (x - 11)(x^2 - 1)$   
 $= (x - 11)(x + 1)(x - 1)$
61.  $5s^4 - 125s^2 = 5s^2(s^2 - 25) = 5s^2(s + 5)(s - 5)$
62.  $147n^5 - 3n^3 = 3n^3(49n^2 - 1) = 3n^3(7n + 1)(7n - 1)$
63.  $2z^3 + 2z^2 - 60z = 2z(z^2 + z - 30) = 2z(z + 6)(z - 5)$
64.  $x^3 + 5x^2 - x - 5 = x^2(x + 5) - (x + 5)$   
 $= (x + 5)(x^2 - 1)$   
 $= (x + 5)(x + 1)(x - 1)$
65.  $2b^3 + 3b^2 - 8b - 12 = b^2(2b + 3) - 4(2b + 3)$   
 $= (2b + 3)(b^2 - 4)$   
 $= (2b + 3)(b + 2)(b - 2)$
66.  $x^3 + x^2 - 6x - 6 = x^2(x + 1) - 6(x + 1)$   
 $= (x + 1)(x^2 - 6)$

### Chapter 9 Test (p. 621)

1.  $\frac{a^2 - 4a + 6}{-3a^2 + 13a + 1}$   
 $\frac{-2a^2 + 9a + 7}{-2a^2 + 9a + 7}$
2.  $(5x^2 - 2) + (8x^3 + 2x^2 - x + 9)$   
 $= 8x^3 + (5x^2 + 2x^2) - x + (-2 + 9)$   
 $= 8x^3 + 7x^2 - x + 7$
3.  $\frac{15n^2 + 7n - 1}{-(4n^2 - 3n - 8)} \rightarrow \frac{15n^2 + 7n - 1}{+4n^2 + 3n + 8}$   
 $\frac{15n^2 + 7n - 1}{11n^2 + 10n + 7}$

4.  $(9c^3 - 11c^2 + 2c) - (-6c^2 - 3c + 11)$   
 $= 9c^3 - 11c^2 + 2c + 6c^2 + 3c - 11$   
 $= 9c^3 + (-11c^2 + 6c^2) + (2c + 3c) - 11$   
 $= 9c^3 - 5c^2 + 5c - 11$
5.  $\frac{2z + 9}{\times \frac{z - 7}{-14z - 63}}$   
 $\frac{2z^2 + 9z}{2z^2 - 5z - 63}$
6.  $\frac{5m - 8}{\times \frac{5m - 7}{-35m + 56}}$   
 $\frac{25m^2 - 40m}{25m^2 - 75m + 56}$
7.  $(b + 2)(-b^2 + 4b - 3)$   
 $= -b^2(b + 2) + 4b(b + 2) - 3(b + 2)$   
 $= -b^3 - 2b^2 + 4b^2 + 8b - 3b - 6$   
 $= -b^3 + 2b^2 + 5b - 6$
8.  $\frac{5 + 7y}{\times \frac{1 - 9y}{-45y - 63y^2}}$   
 $\frac{5 + 7y}{5 - 38y - 63y^2}$
9.  $(2x^2 - 3x + 5)(x - 4)$   
 $= 2x^2(x - 4) - 3x(x - 4) + 5(x - 4)$   
 $= 2x^3 - 8x^2 - 3x^2 + 12x + 5x - 20$   
 $= 2x^3 - 11x^2 + 17x - 20$
10.  $(5p - 6)(5p + 6) = (5p)^2 - 6^2 = 25p^2 - 36$
11.  $(12 - 3g)^2 = 12^2 - 2(12 \cdot 3g) + (3g)^2$   
 $= 144 - 72g + 9g^2$
12.  $(2s + 9t)^2 = (2s)^2 + 2(2s \cdot 9t) + (9t)^2$   
 $= 4s^2 + 36st + 81t^2$
13.  $(11a - 4b)(11a + 4b) = (11a)^2 - (4b)^2$   
 $= 121a^2 - 16b^2$
14.  $x^2 + 8x + 7 = (x + 1)(x + 7)$
15.  $2n^2 - 11n + 15 = (2n - 5)(n - 3)$
16.  $-12r^2 + 5r + 3 = -(12r^2 - 5r - 3)$   
 $= -(3r + 1)(4r - 3)$
17.  $t^2 - 10t + 25 = t^2 - 2(5 \cdot t) + 5^2 = (t - 5)^2$
18.  $-3n^2 + 75 = -3(n^2 - 25)$   
 $= -3(n^2 - 5^2)$   
 $= -3(n + 5)(n - 5)$
19.  $3x^2 + 29x - 44 = (3x - 4)(x + 11)$
20.  $x^2 - 49 = x^2 - 7^2 = (x + 7)(x - 7)$
21.  $2a^4 + 21a^3 + 49a^2 = a^2(2a^2 + 21a + 49)$   
 $= a^2(2a + 7)(a + 7)$
22.  $y^3 + 2y^2 - 81y - 162 = y^2(y + 2) - 81(y + 2)$   
 $= (y + 2)(y^2 - 81)$   
 $= (y + 2)(y + 9)(y - 9)$

## Chapter 9, continued

23.  $25a = 10a^2$   
 $0 = 10a^2 - 25a$   
 $0 = 5a(2a - 5)$   
 $5a = 0$  or  $2a - 5 = 0$   
 $a = 0$  or  $a = \frac{5}{2}$
24.  $21z^2 + 85z - 26 = 0$   
 $(3z + 13)(7z - 2) = 0$   
 $3z + 13 = 0$  or  $7z - 2 = 0$   
 $z = -\frac{13}{3}$  or  $z = \frac{2}{7}$
25.  $x^2 - 22x = -121$   
 $x^2 - 22x + 121 = 0$   
 $x^2 - 2(11 \cdot x) + 11^2 = 0$   
 $(x - 11)^2 = 0$   
 $x - 11 = 0$   
 $x = 11$
26.  $a^2 - 11a + 24 = 0$   
 $(a - 3)(a - 8) = 0$   
 $a - 3 = 0$  or  $a - 8 = 0$   
 $a = 3$  or  $a = 8$
27.  $t^2 + 7t = 60$   
 $t^2 + 7t - 60 = 0$   
 $(t + 12)(t - 5) = 0$   
 $t + 12 = 0$  or  $t - 5 = 0$   
 $t = -12$  or  $t = 5$
28.  $4x^2 = 22x + 42$   
 $4x^2 - 22x - 42 = 0$   
 $2(2x^2 - 11x - 21) = 0$   
 $2(2x + 3)(x - 7) = 0$   
 $2x + 3 = 0$  or  $x - 7 = 0$   
 $x = -\frac{3}{2}$  or  $x = 7$
29.  $56b^2 + b = 1$   
 $56b^2 + b - 1 = 0$   
 $(8b - 1)(7b + 1) = 0$   
 $8b - 1 = 0$  or  $7b + 1 = 0$   
 $b = \frac{1}{8}$  or  $b = -\frac{1}{7}$
30.  $n^3 - 121n = 0$   
 $n(n^2 - 121) = 0$   
 $n(n + 11)(n - 11) = 0$   
 $n = 0$  or  $n + 11 = 0$  or  $n - 11 = 0$   
 $n = -11$  or  $n = 11$

31.  $a^3 + a^2 = 64a + 64$   
 $a^3 + a^2 - 64a - 64 = 0$   
 $a^2(a + 1) - 64(a + 1) = 0$   
 $(a + 1)(a^2 - 64) = 0$   
 $(a + 1)(a + 8)(a - 8) = 0$   
 $a + 1 = 0$  or  $a + 8 = 0$  or  $a - 8 = 0$   
 $a = -1$  or  $a = -8$  or  $a = 8$

32. a.  $h = -16t^2 + vt + s$   
 $h = -16t^2 + 4t$   
b.  $0 = -16t^2 + 4t$   
 $0 = -4t(4t - 1)$   
 $-4t = 0$  or  $4t - 1 = 0$   
 $t = 0$  or  $t = \frac{1}{4}$

The solution  $t = 0$  represents the time at the beginning of the jump. The cricket will land back on the ground in  $\frac{1}{4}$  of a second.

33. a. Area of poster 1 = Area of poster 2  
 $(3w)(w) = 2w(w + 2)$   
 $3w^2 = 2w^2 + 4w$   
b.  $3w^2 = 2w^2 + 4w$   
 $w^2 - 4w = 0$   
 $w(w - 4) = 0$   
 $w = 0$  or  $w - 4 = 0$   
 $w = 4$

Because the width cannot be zero, the width of poster 1 is 4 feet. So, the dimensions of the posters are:

Poster 1: 4 feet by 12 feet

Poster 2: 6 feet by 8 feet

34.  $h = -16t^2 + vt + s$   
 $h = -16t^2 + 225$   
 $0 = -16t^2 + 225$   
 $0 = 15^2 - (4t)^2$   
 $0 = (15 + 4t)(15 - 4t)$   
 $15 + 4t = 0$  or  $15 - 4t = 0$   
 $t = -\frac{15}{4}$  or  $t = \frac{15}{4} = 3.75$

A negative solution does not make sense in this situation, so  $t = -\frac{15}{4}$  can be disregarded. The drop of paint reaches the ground in 3.75 seconds.

35. a. Volume = length • width • height  
 $= (x + 6)(x - 2)(x - 1)$   
 $= (x^2 + 4x - 12)(x - 1)$   
 $= x^3 + 3x^2 - 16x + 12$

## Chapter 9, continued

$$\begin{aligned} \text{b. } 60 &= x^3 + 3x^2 - 16x + 12 \\ 0 &= x^3 + 3x^2 - 16x - 48 \\ 0 &= x^2(x + 3) - 16(x + 3) \\ 0 &= (x + 3)(x^2 - 16) \\ 0 &= (x + 3)(x + 4)(x - 4) \\ x + 3 &= 0 \quad \text{or} \quad x + 4 = 0 \quad \text{or} \quad x - 4 = 0 \\ x &= -3 \quad \text{or} \quad x = -4 \quad \text{or} \quad x = 4 \end{aligned}$$

A dimension cannot be negative, so  $x = -3$  and  $x = -4$  can be disregarded. Because  $x = 4$  inches, the dimensions of the box are 10 inches long, 2 inches wide and 3 inches high.

### Standardized Test Preparation (pp. 622–623)

1. Full credit; the solution is complete and correct, and the reasoning is correctly explained.
2. Partial credit; the solution is complete, but an algebraic error was made resulting in incorrect solutions, and the student incorrectly interpreted the solutions in the real-life context.

### Standardized Test Practice (pp. 624–625)

1. a. When  $v = 10$  and  $s = 0$ :

$$\begin{aligned} h &= -16t^2 + vt + s \\ h &= -16t^2 + 10t \end{aligned}$$

- b.  $0 = -16t^2 + 10t$

$$\begin{aligned} 0 &= -2t(8t - 5) \\ -2t &= 0 \quad \text{or} \quad 8t - 5 = 0 \\ t &= 0 \quad \text{or} \quad t = \frac{5}{8} \end{aligned}$$

The zeros of the function are 0 and  $\frac{5}{8}$ . The zero  $t = 0$  seconds means that the cat is on the ground at the start of its jump, and the zero  $t = \frac{5}{8}$  second means that the cat lands back on the ground after  $\frac{5}{8}$  second.

2. a. Volume = length  $\cdot$  width  $\cdot$  height

$$\begin{aligned} &= (18 - w)(w)(w + 2) \\ &= -w^3 + 16w^2 + 36w \end{aligned}$$

- b.  $576 = -w^3 + 16w^2 + 36w$

$$\begin{aligned} 0 &= -w^3 + 16w^2 + 36w - 576 \\ 0 &= -w^2(w - 16) + 36(w - 16) \\ 0 &= (w - 16)(36 - w^2) \\ 0 &= (w - 16)(6 + w)(6 - w) \end{aligned}$$

$$\begin{aligned} w - 16 &= 0 \quad \text{or} \quad 6 + w = 0 \quad \text{or} \quad 6 - w = 0 \\ w &= 16 \quad \text{or} \quad w = -6 \quad \text{or} \quad w = 6 \end{aligned}$$

The width cannot be negative, so disregard  $-6$ . The length of the tank is greater than 10 inches. If  $w = 16$ , the length would only be 2 inches which is less than 10. If  $w = 6$ , the length would be 12 inches, which is greater than 10. So, the width must be 6 inches, the length 12 inches and the height 8 inches.

3. a.  $h = -16t^2 + vt + s$

$$\begin{aligned} \text{Let } v &= 36 \text{ and } s = 5. \\ h &= -16t^2 + 36t + 5 \end{aligned}$$

$$\begin{aligned} \text{b. } 25 &= -16t^2 + 36t + 5 \\ 0 &= -16t^2 + 36t - 20 \\ 0 &= -4(4t^2 - 9t + 5) \\ 0 &= -4(4t - 5)(t - 1) \\ 4t - 5 &= 0 \quad \text{or} \quad t - 1 = 0 \\ t &= \frac{5}{4} \quad \text{or} \quad t = 1 \end{aligned}$$

The ball reaches a height of 25 feet twice, after 1 second (on its way up), and after  $\frac{5}{4}$  seconds (on its way down).

4. a. Because the pencil falls, its initial vertical velocity is 0 feet per second.

- b.  $h = -16t^2 + vt + s$

$$\begin{aligned} h &= -16t^2 + 4 \\ 0 &= -16t^2 + 4 \\ 0 &= -4(4t^2 - 1) \\ 0 &= -4(2t + 1)(2t - 1) \\ 2t + 1 &= 0 \quad \text{or} \quad 2t - 1 = 0 \\ t &= -\frac{1}{2} \quad \text{or} \quad t = \frac{1}{2} \end{aligned}$$

A negative solution does not make sense in this situation, so disregard  $-\frac{1}{2}$ . The pencil hits the ground after  $\frac{1}{2}$  second.

5. a. The number of foreign language students can be modeled by the percent ( $p$ ) times the total number of students enrolled ( $S$ ).

$n$  = number of foreign language class students

$$\begin{aligned} n &= S \cdot p \\ &= (27.5x^2 - 336x + 12,400)(0.008x + 0.336) \\ &= 27.5x^2(0.008x + 0.336) - 336x(0.008x + 0.336) \\ &\quad + 12,400(0.008x + 0.336) \\ &= 0.22x^3 + 9.24x^2 - 2.688x^2 - 112.896x + 99.2x \\ &\quad + 4166.4 \\ &= 0.22x^3 + 6.552x^2 - 13.696x + 4166.4 \end{aligned}$$

- b. For 2000, let  $x = 15$ .

$$\begin{aligned} n &= 0.22(15)^3 + 6.552(15)^2 - 13.696(15) + 4166.4 \\ &= 6177.66 \end{aligned}$$

In 2000 there were about 6,177,000 public school students enrolled in a foreign language class in the U.S.

6. a. Area =  $16x + 8x - x^2$

$$\begin{aligned} 80 &= 24x - x^2 \\ 0 &= 24x - x^2 - 80 \\ 0 &= -(x^2 - 24x + 80) \\ 0 &= -(x - 20)(x - 4) \\ x - 20 &= 0 \quad \text{or} \quad x - 4 = 0 \\ x &= 20 \quad \text{or} \quad x = 4 \end{aligned}$$

Reject  $x = 20$ . The width of the paths will be 4 feet.

## Chapter 9, continued

b. The solution  $x = 20$  does not make sense in this situation because a width of 20 feet would be greater than the largest dimension of the garden.

7. The tunnel width at the base is the distance between the zeros of the function.

$$\begin{aligned} y &= -0.2x(x - 20) \\ 0 &= -0.2x(x - 20) \\ -0.2x &= 0 \quad \text{or} \quad x - 20 = 0 \\ x &= 0 \quad \text{or} \quad x = 20 \end{aligned}$$

The zeros occur at  $x = 0$  and  $x = 20$ . The distance between the zeros is 20, so the tunnel is 20 feet wide at its base.

8. D;  $25x^2 - 144 = (5x)^2 - 12^2 = (5x - 12)(5x + 12)$

9. D;  $(x + 4)(x - 12) = 0$

$$\begin{aligned} x + 4 &= 0 \quad \text{or} \quad x - 12 = 0 \\ x &= -4 \quad \text{or} \quad x = 12 \end{aligned}$$

The solutions are  $-4$  and  $12$ .

10. A;  $x^2 - 26 = 11x$

$$\begin{aligned} x^2 - 11x - 26 &= 0 \\ (x - 13)(x + 2) &= 0 \\ x - 13 &= 0 \quad \text{or} \quad x + 2 = 0 \\ x &= 13 \quad \text{or} \quad x = -2 \end{aligned}$$

The solutions are  $-2$  and  $13$ .

11.  $x^2 - 20x + 100 = 0$

$$\begin{aligned} x^2 - 2(10 \cdot x) + 10^2 &= 0 \\ (x - 10)^2 &= 0 \\ x - 10 &= 0 \\ x &= 10 \end{aligned}$$

12.  $(x + 3)^2 = x^2 + 2(x \cdot 3) + 3^2 = x^2 + 6x + 9$

So,  $b = 6$ .

13.  $6x^4 - 3x^2 + 10x$  is a polynomial of degree 4 because the greatest degree of any of its terms is 4.

14.  $f(x) = 4x^2 - 36$

$$\begin{aligned} 0 &= 4(x^2 - 9) \\ 0 &= 4(x + 3)(x - 3) \\ x + 3 &= 0 \quad \text{or} \quad x - 3 = 0 \\ x &= -3 \quad \text{or} \quad x = 3 \end{aligned}$$

The zeros of the function are 3 and  $-3$ . The greater of the zeros is 3.

15. Area = length  $\cdot$  width

$$\begin{aligned} 28 &= (w + 3)w \\ 0 &= w^2 + 3w - 28 \\ 0 &= (w + 7)(w - 4) \\ w + 7 &= 0 \quad \text{or} \quad w - 4 = 0 \\ w &= -7 \quad \text{or} \quad w = 4 \end{aligned}$$

A negative width does not make sense, so the width of the rectangle is 4 inches.

16. Let  $v = 0$  and  $s = 144$ .

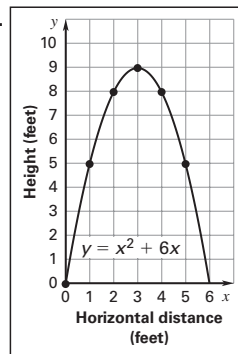
$$\begin{aligned} h &= -16t^2 + vt + s \\ h &= -16t^2 + 144 \\ h &= -16(t^2 - 9) \\ 0 &= -16(t + 3)(t - 3) \\ t + 3 &= 0 \quad \text{or} \quad t - 3 = 0 \\ t &= -3 \quad \text{or} \quad t = 3 \end{aligned}$$

A negative solution does not make sense in this situation, so disregard  $t = -3$ . The pine cone lands on the ground after 3 seconds.

17. a.

$x$	0	1	2	3	4	5
$y$	0	5	8	9	8	5

- b.



- c. From the graph, it appears that the width of the base is 6 feet.

$$\begin{aligned} \text{Check: } 0 &= -x^2 + 6x \\ 0 &= x(-x + 6) \\ x &= 0 \quad \text{or} \quad -x + 6 = 0 \\ & \qquad \qquad \qquad x = 6 \end{aligned}$$

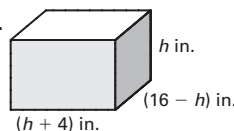
The distance between the zeros is 6, so the width of the base is 6 feet.

- d. From the graph, it appears that the arch reaches a height of 9 feet at only one point, its maximum.

$$\begin{aligned} \text{Check: } 9 &= -x^2 + 6x \\ 0 &= -x^2 + 6x - 9 \\ 0 &= -(x^2 - 6x + 9) \\ 0 &= -(x - 3)^2 \\ x - 3 &= 0 \\ x &= 3 \end{aligned}$$

Because the only solution is  $x = 3$ , then the arch reaches a height of 9 feet only once, at a horizontal distance of 3 feet.

18. a.



- b. Volume = length  $\cdot$  width  $\cdot$  height

$$\begin{aligned} &= (h + 4)(16 - h)(h) \\ &= -h^3 + 12h^2 + 64h \end{aligned}$$

## Chapter 9, continued

c.  $768 = -h^3 + 12h^2 + 64h$

$$0 = -h^3 + 12h^2 + 64h - 768$$

$$0 = -h^2(h - 12) + 64(h - 12)$$

$$0 = (h - 12)(64 - h^2)$$

$$0 = (h - 12)(8 + h)(8 - h)$$

$$h - 12 = 0 \quad \text{or} \quad 8 + h = 0 \quad \text{or} \quad 8 - h = 0$$

$$h = 12 \quad \text{or} \quad h = -8 \quad \text{or} \quad h = 8$$

The height cannot be negative, so disregard  $h = -8$ .

Two sets of possible dimensions are:

Box 1:

$$\text{Length} = h + 4 = 12 \text{ in.}$$

$$\text{Width} = 16 - h = 8 \text{ in.}$$

$$\text{Height} = h = 8 \text{ in.}$$

Box 2:

$$\text{Length} = h + 4 = 16 \text{ in.}$$

$$\text{Width} = 16 - h = 4 \text{ in.}$$

$$\text{Height} = h = 12 \text{ in.}$$

d. Surface area =  $2\ell w + 2wh + 2\ell h$

Box 1 surface area

$$= 2(12 \cdot 8) + 2(8 \cdot 8) + 2(12 \cdot 8) = 512 \text{ in.}^2$$

Box 2 surface area

$$= 2(16 \cdot 4) + 2(4 \cdot 12) + 2(16 \cdot 12) = 608 \text{ in.}^2$$

The dimensions 12 inches by 8 inches by 8 inches result in a box with the least possible surface area.