# Answers

## Chapter 1

### Get Ready, pages 4–7

**1.** **a)** 6 **b)** $-8$ **c)** $-11$

**d)** $-4$ **e)** 2 **f)** 3

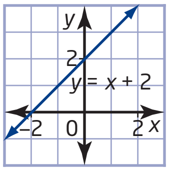
**2.** **a)** 0 **b)** 2 **c)** $-4$

**d)** 12 **e)** 2 **f)** $-3$

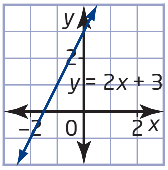
**3.** **a)** $7x - 2y$ **b)** $7a - 11b$ **c)** $5x - 5y$

**4.** **a)** $-2x + 35y$ **b)** $-7x - 13y$ **c)** $-a + 16b - 4$

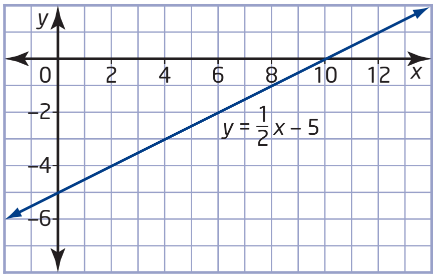
**5.** **a)**



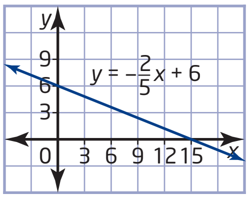

**b)**



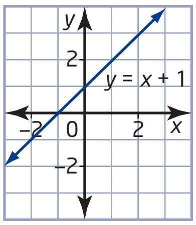

**c)**



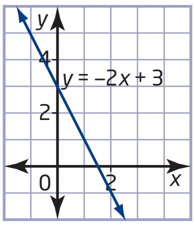

**d)**



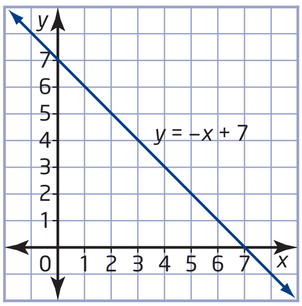

**6.** **a)** $y = x + 1$



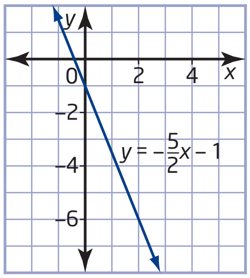

**b)** $y = -2x + 3$



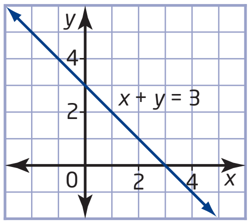

**c)** $y = -x + 7$



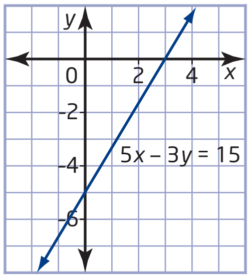

**d)** $y = -\frac{5}{2}x - 1$



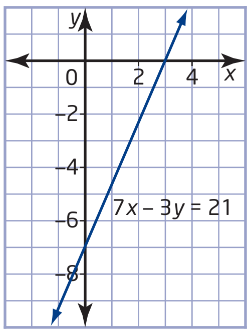

**7.** **a)** $x$-intercept 3, $y$-intercept 3



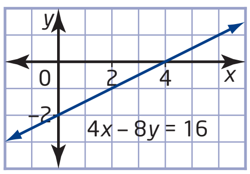

**b)** $x$-intercept 3, $y$-intercept $-5$

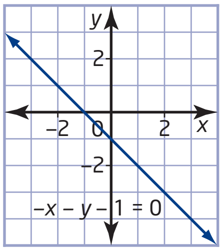


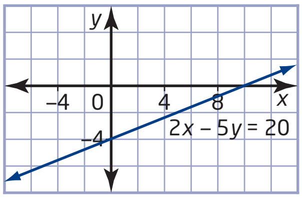

**c)** $x$-intercept 3, $y$-intercept $-7$

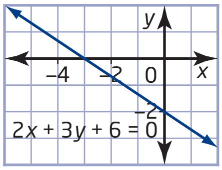


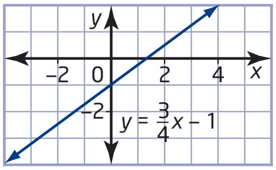

**d)** $x$-intercept 4, $y$-intercept $-2$

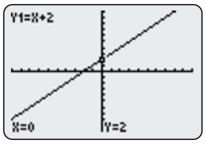


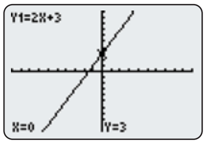
8. a) 

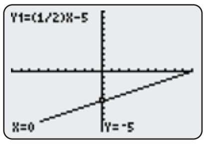

b) 

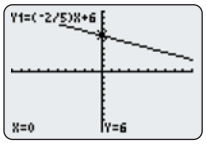

c) 

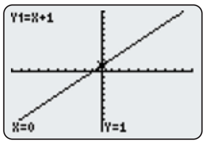

d) 

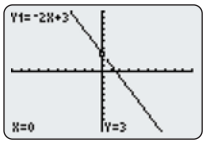

9. a) 

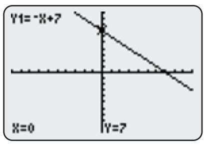

b) 

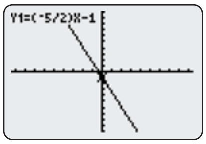

c) 


d) 


10. a) 

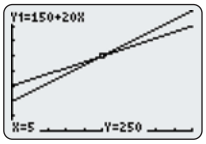

b) 

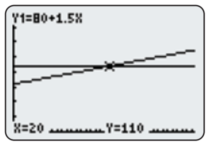

c) 

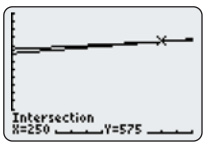

d) 


11. a) 4.2 L b) 0.72 kg c) 44 g
12. a) \$80 b) \$34.80 c) \$46.50 d) \$562.50
13. a) 7 b) 2 c) −2
14. Answers will vary.
15. Answers will vary.

## 1.1 Connect English With Mathematics and Graphing Lines, pages 8–19

1. a) $2x - 7$ b) $\frac{1}{2}x + 4$ c) $(x - 6)y$ d) $x + \frac{2}{3}$
2. a) $2d$ b) $0.2n$ c) $2l$ d) $0.07p$
3. a) $\frac{1}{5}n - 17 = 41$ b) $5 - 2n = 7n + 3$
c) $5n = 825$ d) $l + w = 96$
4. a) decreased b) subtracted
c) minus d) less than or equal to
5. a) addition b) Answers will vary.
6. Answers may vary. For example: An expression is a combination of numbers, operations, and/or variables that can be evaluated. An equation equates two expressions.
7. C
8. a) (2, 7) b) (−3, −4) c) (−20, −12) d) (3, 7)
9. a) (2, 1) b) (−2, −1) c) (2, −3) d) (2, 1)
10. a) (3, −2) b) (−4.67, 8)
c) (1.45, 4.73) d) (−1.29, 7.86)
e) (−1.49, 0.62) f) (1.26, −4.75)
11. a) $C = 150 + 20m$ b) $C = 100 + 30m$
c) 

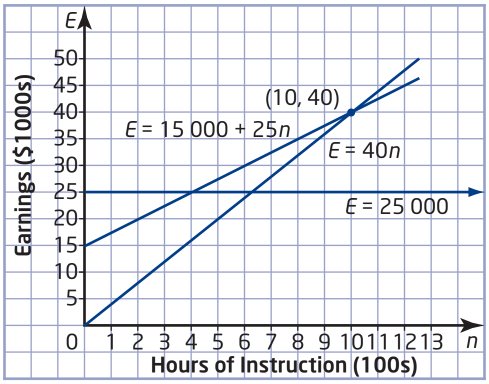
d) (5, 250)
e) Answers may vary. For example: The point of intersection represents the number of months it will take for the costs to be the same at both clubs.
f) Answers may vary. For example: You should join CanFit because it will be cheaper for 1 year.
12. a) $C = 10 + 3n$ b) $C = 7 + 4n$ c) (3, 19)
d) Answers may vary. For example: The cost is the same at both stores when you rent three video games. The cost is \$19.
13. a) $C = 15h$ b) $C = 150$ c) (10, 150)
d) Jeff charges the same price for 10 h of work as Hesketh's Snow Removal charges for the season.
14. a) $C = 5000 + 75n$
b) $C = 7500 + 50n$
c) 100
d) Limestone Hall is less expensive for fewer than 100 guests.
e) Answers will vary. For example: convenience of location, parking availability, reputation for good food, attractiveness of the hall
15. a) $E = 80 + 1.50n$
b) $E = 110$
c) 20 pairs of jeans


16. \$500 was invested in the account paying 5%/year interest and \$4500 was invested in the GIC paying 7.2%/year interest.
17. a) $C = 525 + 0.20d$
b) $C = 500 + 0.30d$
c) 

d) The cost of \$575 is the same when the Clarkes rent the car from either of the two companies and drive 250 km.

**18. a) i)** $E = 25\ 000$ **ii)** $E = 40n$ **iii)** $E = 15\ 000 + 25n$

**b)**




**c)** If Alain is going to give fewer than 400 h of instruction, then package (i) is best. For 400 h, packages (i) and (ii) pay the same amount, $25 000. For more than 400 h but fewer than 1000 h, package (ii) pays more. For 1000 h, packages (ii) and (iii) pay the same, $40 000. For more than 1000 h, package (iii) pays the most. It would not make sense for him to work more than 1250 h (25 h per week for 50 weeks), because that is the most he can work for packages (ii) and (iii). If he did work more than 1250 h, he would have to go with package (i), the flat rate of $25 000.

**19.** The three lines intersect at the same point.

**20.** Answers may vary. For example:

**a)** No, because they represent the same line and intersect everywhere.

**b)** No, because the lines are parallel and do not intersect.

**c)** If two lines have the same slopes and $y$-intercepts, then there is an infinite number of solutions. If two lines have the same slope and different $y$-intercepts, then there is no solution. If two lines have different slopes, then there is one solution.

**21.** $(-2, -6)$ and $(2, -2)$. The second equation is not linear because it has an $x^2$-term.

**22. a)** 31 **b)** $2n + 1$

**23.** 28%

**24.** C

## 1.2 The Method of Substitution, pages 20–28

**1. a)** $x = 3, y = 5$ **b)** $x = 9, y = -1$
**c)** $x = 1, y = 1$ **d)** $x = 4, y = -3$

**2. a)** equation 1: $x = -2y + 5$ **b)** equation 1: $y = -2x + 6$
**c)** equation 2: $x = 3y - 2$ **d)** equation 1: $y = 3x - 5$
**e)** either equation 1: $(y = 2x - 2)$ or equation 2: $(y = -4x + 16)$

**3.** No. $(3, -5)$ satisfies the first equation but not the second equation.

**4. a)** $x = \frac{2}{3}, y = \frac{7}{6}$ **b)** $x = 2, y = -1$
**c)** $m = 1, n = 0$ **d)** $a = 8, b = -10$
**e)** $x = 1, y = 2$

**5. a)** $\left(-\frac{4}{5}, -\frac{33}{5}\right)$ **b)** $\left(\frac{19}{2}, -\frac{31}{2}\right)$ **c)** $\left(\frac{1}{3}, \frac{2}{3}\right)$
**d)** $(-1, -5)$ **e)** $(4, 1)$

**6.** Answers may vary. For example:

**a)** Let $S$ represent the number of hours that Samantha works. Let $A$ represent the number of hours that Adriana works.

**b)** $S = 2A$ **c)** $S + A = 39$

**d)** Samantha worked 26 h and Adriana worked 13 h.

**7.** Answers may vary. For example:

**a)** Let $J$ represent the number of T-shirts bought by Jeff and $S$ represent the number of T-shirts bought by Stephen. Then, $J + S = 15$.

**b)** $S = 2J - 3$

**c)** Jeff bought 6 T-shirts and Stephen bought 9 T-shirts.

**d)** Jeff spent $53.94 and Stephen spent $80.91, before tax.

**8.** Answers may vary. For example:

**a)** Let $g$ represent the number of goals and $a$ represent the number of assists. Then, $2g + a = 86$; $g = a - 17$.

**b)** $g = 23$, $a = 40$

**c)** Ugo scored 23 goals and made 40 assists.

**9.** Answers may vary. For example:

**a)** Let $C$ represent the cost of renting a hall and $n$ be the cost of a meal. Then, $C = 500 + 15n$; $C = 350 + 18n$.

**b)** 50 guests

**10.** 2.5 h

**11.** The companies charge the same for 200 km. It is better to rent from Joe's Garage for distances less than 200 km.

**12.** Answers may vary. For example: It is not easy to isolate either of the variables.

**13.** Answers may vary. For example: It is easy to isolate $y$ in either equation. Both lines are simple to graph.

**14. a)** $(-1, 6), (1, 2), (2, 3)$

**b)** Explanations may vary. For example: Yes, because the slope of the first line, $m_1$, and the slope of the third line, $m_3$, are negative reciprocals.

**15.** 6 wins

**16.** Answers may vary. For example:

**a)** Let $C$ represent the cost of renting a car and $d$ represent the number of kilometres driven. Then, $C = 90$.

**b)** $C = 40 + 0.25d$

**c)** The costs are the same for driving a distance of 200 km.

**d)** The mid-size car costs less for driving fewer than 200 km during a 1-day car rental.

**e)** The full-size car is cheaper by $10.

**18.** 8750 adults

**19. a)** You get $-2 = 9$, which is impossible.

**b)** Since the lines are parallel and distinct, the lines do not intersect. There is no solution.

**20. a)** $x = 5, y = 4$ **b)** $x = 0.5, y = -0.5$

**21.** $(-4, 5)$; $k = -5$

**22.** $\frac{n}{6}(n + 1)(n + 2)$

**23.** A

## 1.3 Investigate Equivalent Linear Relations and Equivalent Linear Systems, pages 29–33

**1.** A and C

**2.** C

**3.** Answers may vary. For example:

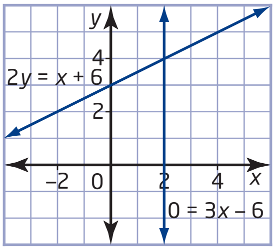
**a)** $2y = 6x - 4$; $3y = 9x - 6$

**b)** $x + 2y = 4$; $2x + 4y = 8$

**c)** $5y = 3x + 10$; $10y = 6x + 20$

**d)** $4x + 2y = 5$; $2x + y = 2.5$

4. Answers may vary. For example: $2l + 2w = 24$; $l + w = 12$
5. Answers may vary. For example: $0.05n + 0.10d = 0.70$; $5n + 10d = 70$
6. The systems are equivalent because equation ③ is equation ① divided by 3, and equation ④ is equation ② multiplied by 2.
7. **a)** Since both systems have the same solution, (2, 4), they are equivalent linear systems.




**b)** Add: equation ① + equation ②.
**c)** Subtract: equation ① − equation ②.
8. **a)** Equation ③ was obtained by multiplying both sides of equation ① by three and then subtracting $2x$ from both sides. Equation ④ was obtained by multiplying both sides of equation ② by three and then adding $x$ to both sides. The linear system formed by equation ③ and equation ④ is an equivalent linear system to the linear system formed by equation ① and equation ② and has the same point of intersection.
**b)** You expect to see only two distinct lines intersecting at the point (3, 1).
9. Answers will vary.
10. 1729
11. B

### 1.4 The Method of Elimination, pages 34–41

1. **a)** $x = 1, y = 1$ **b)** $x = -2, y = -1$
**c)** $x = 1, y = 2$ **d)** $x = -1, y = -3$
2. **a)** $x = -1, y = -3$ **b)** $x = 1, y = 5$
**c)** $x = 2, y = 4$ **d)** $x = -1, y = 1$
3. **a)** $(-2, 2)$ **b)** $(-1, 3)$ **c)** $(3, 4)$ **d)** $(2, 0)$
4. **a)** $x = \frac{1}{4}, y = 1$ **b)** $x = 2, y = -5$
**c)** $x = 6, y = 9$ **d)** $x = 1, y = 2$
5. **a)** $x = 3, y = 2$ **b)** $m = -1, n = 5$
**c)** $a = 6, b = 2$ **d)** $h = -1, k = -2$
6. **a)** $(3, 4)$ **b)** $(-3, -4)$
**c)** $\left(\frac{5}{2}, \frac{19}{4}\right)$ **d)** $\left(-\frac{1}{2}, 3\right)$
7. **a)** $x = -\frac{1}{2}, y = -\frac{2}{3}$ **b)** $x = 7, y = -2$
**c)** $a = -2, b = -1$ **d)** $u = 8, v = 6$
8. **a)** 11 **b)** 17
9. **a)** 10 large bottles **b)** 27 small bottles
10. **a)** $x = \frac{29}{14}, y = -\frac{2}{7}$ **b)** $x = \frac{29}{14}, y = -\frac{2}{7}$
**c)** Answers will vary.
11. Answers may vary. For example: Multiply the first equation by 4 and the second equation by 3, and then subtract the equations. Solve for $y$, substitute this value of $y$ into the first equation, and then solve for $x$.
12. **a)** $x = -1, y = -5$ **b)** $a = 4.5, b = 6.5$
**c)** $k = 5, n = -3$
13. Answers may vary. For example: Brent multiplied each equation by 10 to write equivalent equations without decimals. The equivalent equations, without decimals, are easier to solve. $x = -1, y = -3$
14. **a)** $x = 5, y = -1$ **b)** $a = 3, b = -4$
15. \$4
16. **a)** \$50/day **b)** \$0.20/km
17. **a)** $C = 250 + 0.22d$ **b)** $C = 96 + 0.50d$
**c)** If they drive 550 km, the cost of renting either car is \$371.
**d)** The daughter's suggestion is less expensive.
18. Answers may vary. For example: You get $0 = 18$, which is impossible. On a graph, the lines are parallel and distinct so there is no solution.
20. **a)** $m = -4, n = -2$ **b)** $a = 6, b = 8$
**c)** $t = -4, w = 7$
21. $(x, y) = \left(\frac{ce - bf}{ae - bd}, \frac{cd - af}{bd - ae}\right)$, where $ae \neq bd$.
22. $(x, y, z) = (4, -5, 3)$

### 1.5 Solve Problems Using Linear Systems, pages 42–47

1. 24 crocus bulbs and 8 tulip bulbs
2. 10 Beta tapes and 7 VHS tapes
3. 30 cars and 14 vans
4. \$2650 at 8%/year and \$400 at 7.5%/year
5. Answers may vary. For example: The numbers are smaller and it is easier to isolate one variable in both equations.
6. **a)** Answers will vary. $(-23, -77)$
**b)** $(-23, -77)$
7. average rowing speed 3.5 km/h, speed of current 1.5 km/h
8. wind speed 50 km/h, speed of plane 550 km/h
9. 15 L of 3% milk, 5 L of 15% cream
10. 6 L of 30% sulphuric acid solution, 4 L of 60% sulphuric acid solution
11. **a)** 10 months **b)** Kool Karate
**c)** Karate Klub
12. 30 medium T-shirts
13. 240 g of granola with 30% nuts, 360 g of granola with 15% nuts
14. 100 g of metal alloy that is 25% copper, 400 g of metal alloy that is 50% copper
15. 32 fruit pies, 20 meat pies
16. \$10 per meal, \$50 per day for accommodation
17. best cruise speed 200 km/h, economy cruise speed 150 km/h
18. 200 km
19. 400 g of 18-karat gold, 200 g of 9-karat gold
20. 83.5%

### Chapter 1 Review, pages 48–49

1. **a)** Let $n$ represent the number of nickels and $d$ represent the number of dimes. $0.05n + 0.10d = 2.50$
**b)** Let $M$ represent Maggie's age and $J$ represent Janice's age. $M + 3 = 2J - 9$
**c)** Let $n$ represent the number. $2n - 9 = \frac{1}{2}n + 6$

2. $(4, -3)$
3. a) $C = 1500 + 25n$ b) $C = 1000 + 30n$
c) 100 guests
d) Allison should choose La Casa if she invites more than 100 guests because it will cost less.
e) She should choose Hastings Hall if she invites fewer than 100 guests because it will cost less.
4. a) $x = -4, y = 2$ b) $x = 6, y = -3$
c) $x = -1, y = 4$ d) $x = 3.75, y = 0.5$
5. 41 chickens
6. Josie should choose the flat rate if she uses the Internet for more than 30 h per month.
7. 21 males, 14 females
8. B
9. a) $(2, -1)$ b) $(1, 1)$ c) $(-1, 1)$ d) $(2, 3)$
10. a) $x = 2, y = 3$ b) $x = 4, y = 11$
c) $a = -1, b = 5$ d) $k = -0.5, h = 0.3$
11. Answers will vary.
12. a) $x = 5, y = 2$ b) $x = -0.1, y = -0.5$
c) $x = -1, y = 2$ d) $x = 4, y = 5$
13. a) 10 km
b) Choose company A for distances greater than 10 km.
14. \$4200 at 5%/year, \$5800 at 3.5%/year
15. average speed of the boat in still water 16 km/h, speed of the current 4 km/h
16. 200 kg of fertilizer with 30% nitrogen, 400 kg of fertilizer with 15% nitrogen
17. Fran earns \$48 000; Winston earns \$32 000.

### Chapter 1 Practice Test, pages 50–51

1. a) Let $m$ represent the number of men and $w$ represent the number of women. $m + w = 20$; $m = w + 7$
b) Let $n$ represent the number. $7 + 2n = 3n$
2. Answers will vary.
3. a) $(7, -1)$ b) $x = 7, y = -1$
4. a) $x = 4, y = -5$ b) $a = 5, b = 0$
c) $x = 1, \ y = -\frac{1}{3}$ d) $m = -6.4, n = -3.6$
5. a) The second equation is three times $y = \frac{2}{3}x - 3$, rearranged.
b) Both linear systems have the same point of intersection, $(-3, -5)$.
c) The first equation is twice $y = 2x + 1$, rearranged. The second equation is six times $y = \frac{2}{3}x - 3$, rearranged.
6. a) $x = 3, y = 5$ b) $x = \frac{5}{2}, \ y = -\frac{5}{3}$
c) $k = 5, h = -2$ d) $p = -2.5, q = -8$
7. a) $x = 1, y = 3$ b) $x = -2, y = -7$
c) $x = -2, y = 2$ d) $x = -1, y = -1$
8. Answers will vary.
9. $(0.2, 3.6)$, $(1, 2)$, $(1.8, 4.4)$
10. a) $G = \frac{1}{2}P$ b) $G + P = 48$
c) Gregory works 16 h; Paul works 32 h.
11. Rolly answered 17 questions correctly.
12. length 33 m, width 15 m
13. adult \$11.65, child \$8.55
14. 11 nickels, 16 dimes
15. They charged \$110 for 2 h of work.
16. a) $x = -2, y = -3$
b) $c = 1.05, d = -2.1875$
c) $x = 36, y = 4$
17. \$20 000 at 5%/year, \$30 000 at 10%/year
18. 320 L of 25% acid solution, 180 L of 50% acid solution
19. 281.25 km by bus, 1618.75 km by airplane

## Chapter 2

### Get Ready, pages 54–55

1. a) 4 b) 3 c) 24 d) 0.25
2. a) $y = x + 2$ b) $y = -3x + 5$
c) $y = \frac{1}{2}x + \frac{7}{4}$ d) $y = \frac{1}{6}x + \frac{5}{3}$
3. a) $\frac{1}{2}$ b) $\frac{1}{2}$ c) $-\frac{2}{3}$ d) $-\frac{1}{4}$
4. a) $\frac{1}{2}$ b) $-\frac{1}{4}$ c) $-\frac{1}{2}$ d) $\frac{12}{73}$
5. a) $y = -2x + 4$ b) $y = \frac{2}{7}x - 14$
c) $y = 4x - 21$ d) $y = -\frac{1}{2}x + 3$
6. a) $y = 2x - 1$ b) $y = \frac{3}{2}x + \frac{5}{2}$
c) $y = \frac{1}{2}x + 3$ d) $y = -2x + 2$
7. a) 3 b) $-\frac{1}{6}$ c) $\frac{1}{4}$ d) $-\frac{4}{3}$
8. a) $y = -3x - 4$ b) $y = \frac{2}{3}x + \frac{5}{3}$
c) $y = -\frac{3}{4}x - \frac{11}{4}$
9. a) 60° b) 2.5 cm
10. If P is any point on the right bisector of line segment AB and Q is the point of intersection of AB and the right bisector, then AQ = QB and ∠PQA = ∠PQB = 90°. Side PQ is common to △PQA and △PQB. Therefore, △PQA is congruent to △PQB (side-angle-side). PA and PB are corresponding sides, so PA = PB.

### 2.1 Midpoint of a Line Segment, pages 56–69

1. a) $(4, 6)$ b) $(1, 3)$
c) $(2, 2)$ d) $\left(-\frac{1}{2}, -2\right)$
2. a) $(4, 8)$ b) $(0, -3)$
c) $(-2, 2)$ d) $(-2, -5)$
3. a) $(1.9, 0.85)$ b) $(-0.4, -4.25)$
c) $(1, 0)$ d) $\left(\frac{13}{16}, -\frac{3}{8}\right)$
4. a) $-\frac{5}{4}$ b) $\frac{12}{17}$
5. $(51.5, 40.9)$
6. $(-4, 3)$

**7.** Answers may vary.
*The Geometer's Sketchpad®* example: Plot the endpoints, and construct the line segment between them. Construct the midpoint of this line segment. Then, select the midpoint and choose **Coordinates** from the **Measure** menu.
Cabri® Jr. example: Choose **Point** from the **F2** menu to plot the endpoints. Choose **Coord. & Eq.** from the **F5** menu, and check the placement of the endpoints. Adjust the endpoints if necessary. Choose **Segment** from the **F2** menu, and construct the line segment between the endpoints. Choose **Midpoint** from the **F3** menu, and construct the midpoint. Then, choose **Coord. & Eq.** again to display the coordinates of the midpoint.

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

**9.** Answers may vary.
*The Geometer's Sketchpad®* example: Plot the vertices of △ABC, and construct the midpoint, M, of side BC. Construct a line through AM. Select the line, and choose **Equation** from the **Measure** menu.
Cabri® Jr. example: Choose **Point** from the **F2** menu, and plot the vertices of △ABC. Choose **Coord. & Eq.** from the **F5** menu, and check the placement of the vertices. Adjust the vertices if necessary. Choose **Segment** from the **F2** menu, and construct the line segment between vertices B and C. Select this line segment and choose **Midpoint** from the **F3** menu. Choose **Line** from the **F2** menu, and construct the line through the midpoint and vertex A. Then, choose **Coord. & Eq.** again to display the equation of the line.

**10. a)** $y = \frac{3}{13}x + \frac{6}{13}$ **b)** $y = 3x - 6$

**11.** Answers may vary.
*The Geometer's Sketchpad®* example:
**a)** Plot the vertices of △PQR. Construct the midpoint, S, of side QR. Construct a line through points P and S. Select the line, and choose **Equation** from the **Measure** menu.
**b)** Construct the midpoint, T, of side PR, and the line though points Q and T. Select the line, and choose **Equation** from the **Measure** menu.
Cabri® Jr. example:
**a)** Choose **Point** from the **F2** menu, and plot the vertices of △PQR. Choose **Coord. & Eq.** from the **F5** menu, and check the placement of the vertices. Adjust the vertices if necessary. Choose **Segment** from the **F2** menu, and construct the line segment between vertices Q and R. Select this line segment, and choose **Midpoint** from the **F3** menu. Choose **Line** from the **F2** menu, and construct the line through the midpoint and vertex P. Then, choose **Coord. & Eq.** again to display the equation of the line.
**b)** Use the method in part a) to construct the midpoint T of side PR and the line through points Q and T. Then, choose **Coord. & Eq.** from the **F5** menu to display the equation of the line.

**12.** $(2a, 1.5b)$; these coordinates are the mean of the $x$-coordinates of the endpoints and the mean of the $y$-coordinates of the endpoints.

**13. a)** $(2, -1)$
**b)** Answers may vary. For example: Let the coordinates of the other endpoint be D($x$, $y$). Solving the equation $\frac{x + 6}{2} = 4$ gives $x = 2$. Similarly, solving the equation $\frac{y + 5}{2} = 2$ gives $y = -1$.
Alternative method: Since the run from C to M is $-2$, subtract 2 from the $x$-coordinate of M to find the $x$-coordinate of D. Since the rise from C to M is $-3$, subtract 3 from the $y$-coordinate of M to find the $y$-coordinate of D.
**c)** Answers may vary. For example: Substitute the coordinates of points C and D into the midpoint formula to confirm that M is the midpoint of CD.

**14.** $(3, -4)$

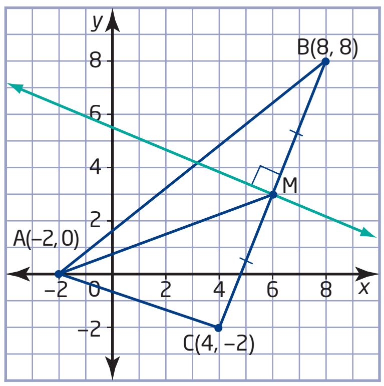
**15. a)** $(-4, 0)$ or $(5, 6)$
**b)** Answers may vary. For example: The centre of the circle could be either point D or point E.

**16.** $y = -x + 1$

**17. a)** Answers may vary. For example: Any point on the right bisector of a line segment is equidistant from the endpoints. Therefore, points on the right bisector of the line segment joining the two towns are possible locations for the relay tower.
**b)** $y = \frac{4}{3}x - 5$

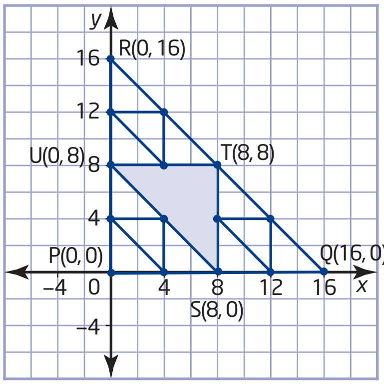
**18.** Answers may vary.
*The Geometer's Sketchpad®* example: Plot the points A(2, 6) and B(10, 0). Construct the line segment AB and the midpoint of AB. Then, construct a perpendicular line through the midpoint. Select the perpendicular line, and choose **Equation** from the **Measure** menu.
Cabri® Jr. example: Choose **Segment** from the **F2** menu, and plot the endpoints at points (2, 6) and (10, 0). Use **Coord. & Eq.** from the **F5** menu to check the placement of the endpoints, and adjust them if necessary. Select the line segment, and choose **Midpoint** from the **F3** menu. Choose **Perp.** from the **F3** menu, and construct the perpendicular line through the midpoint. Then, choose **Coord. & Eq.** again to display the equation of the line.

**19. a)**




**b)** $y = \frac{3}{8}x + \frac{3}{4}$ **c)** $y = -\frac{2}{5}x + \frac{27}{5}$
**d)** Answers may vary. For example: Check that the slopes and $y$-intercepts on the drawing match those in the equations.

**20. a), b), e)**



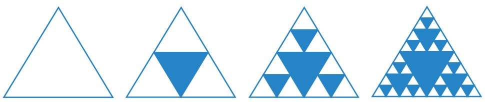

**c)** Answers may vary. For example: Since U is the midpoint of PR, RU = UP = $\frac{1}{2}$PR. Since ST joins the midpoints of two sides of $\triangle$PQR, ST = $\frac{1}{2}$PR. Therefore, ST = RU = UP. Similarly, UT = PS = SQ and RT = TQ = US. Therefore, $\triangle RUT \cong \triangle UPS \cong \triangle STU \cong \triangle TSQ$ (side-side-side).

**d)** The area of $\triangle$STU is $\frac{1}{4}$ the area of $\triangle$PQR.

**f)** The area of one of the smallest triangles is $\frac{1}{4}$ the area of $\triangle$STU and $\frac{1}{16}$ the area of $\triangle$PQR.

**21. b)** Answers may vary. For example: Join the midpoints of the sides of an equilateral triangle to form four equilateral triangles inside the original triangle. Shade the centre triangle. For each of the other three triangles, repeat the process of joining the midpoints to form smaller similar triangles, and shade the centre triangle. The procedure works with any triangle. The area relationships are the same as shown in question 20 since the line segment joining the midpoints of two sides of any triangle is half the length of the third side.

**c)**



**d)** Answers may vary. For example: Sierpinski's triangle is a fractal since all of the smaller triangles in each step are similar to the original triangle.

**22.** 16

**23. a)** (5, 7) and (8, 13)

**b)** Answers may vary. For example: For the first dividing point, add $\frac{1}{3}$ of the run to the $x$-coordinate of the first endpoint and add $\frac{1}{3}$ of the rise to the $y$-coordinate of the first endpoint. For the second dividing point, add $\frac{2}{3}$ of the run to the $x$-coordinate of the first endpoint and add $\frac{2}{3}$ of the rise to the $y$-coordinate of the first endpoint.

**24. a)** A(−1, −2), B(1, 6), C(3, 2)

**b)** Substituting the coordinates of each pair of vertices should give the coordinates of one of the midpoints.

**25. a)** (4, 5, 3)

**b)** $M(x, y, z) = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}, \frac{z_1 + z_2}{2}\right)$

**26.** Answers may vary. For example: All of the points equidistant from the first two towns lie on the right bisector of the line segment joining the two towns. Similarly, all of the points equidistant from the second and third towns lie on the right bisector of the line segment joining them. The point of intersection of these two right bisectors is the only location equidistant from all three towns.

**27. a)** Answers may vary. For example: Latitude and longitude are not linear coordinates since the distance between lines of longitude decreases as the distance from the equator increases. The midpoint formula is accurate only for Cartesian coordinates.

**28.** Explanations may vary.

**a)** Sometimes true: Line segments can bisect each other without being equal in length.

**b)** Never true: Parallel lines have no points in common.

**c)** Always true: The midpoint is the only point that is both on the line segment and equidistant from the endpoints.

**d)** Sometimes true: The midpoint of a line segment is equidistant from the endpoints, but so is every other point on the right bisector of the line segment.

**29.** $c = 10$, $d = 7$

**30.** D

**31.** C

### 2.2 Length of a Line Segment, pages 70–79

**1.** Estimates may vary. Calculated lengths:

**a)** $\sqrt{17}$ **b)** $\sqrt{17}$ **c)** $\sqrt{68}$

**2. a)** $\sqrt{125}$ **b)** $\sqrt{90}$ **c)** $\sqrt{32}$ **d)** 10

**3. a)** 14.6 **b)** 21.3 **c)** $\sqrt{26}$

**4.** 5 km

**5. a)** The school at (0, 5) is closer to Jordan's house.

**b)** Make a scale diagram and measure the distances with a ruler, or use geometry software to plot the points and measure the distances between them.

**6. a)** AB = AC = 10, BC = 16

**b)** 36

**c)** isosceles

**7. a)** Applying the length formula shows that DE = EF = DF = 2. Therefore, $\triangle$DEF is equilateral.

**b)** Answers may vary. For example: any enlargement of $\triangle$DEF, such as (−2, 0), (2, 0), and (0, $2\sqrt{3}$), or any translation, such as (0, 0), (2, 0) and (1, $\sqrt{3}$).

**8.** $\sqrt{\frac{85}{4}}$

**9.** Answers may vary.
*The Geometer's Sketchpad®* example: Plot the points J, K, and L. Construct line segment KL and its midpoint, M. Then, construct and measure line segment JM.
Cabri® Jr. example: Choose **Triangle** from the **F2** menu, and construct △JKL. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the vertices. Adjust the vertices if necessary. Choose **Midpoint** from the **F3** menu, and select side KL. Choose **Segment** from the **F2** menu, and construct the line segment from the midpoint to vertex J. Choose **Measure/D. & Length** from the **F5** menu, and select the median.

**10.** 36 square units

**11.** Answers may vary.
*The Geometer's Sketchpad®* example: Construct the triangle with vertices R, S, and T. Then, select and measure the interior of △RST.
Cabri® Jr. example: Choose **Triangle** from the **F2** menu, and construct △RST. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the points. Adjust the position of a vertex if its coordinates are not correct. Choose **Measure/Area** from the **F5** menu, and select △RST.

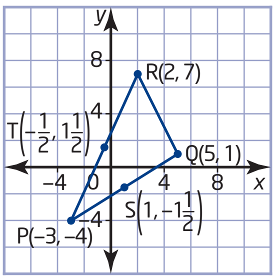
**12.** Applying the length formula shows that
$AC = CB = \sqrt{45} = \frac{1}{2}AB$.

**13. a)** $M\left(1, 2\frac{1}{2}\right)$

**b)** Both distances are $\sqrt{\frac{117}{4}}$, which is half of KL.

**14.** $53.55

**15. a), b)**




**c)** $ST = \frac{1}{2}\sqrt{45}$ and $QR = \sqrt{45}$

**d)** $m_{ST} = m_{QR} = -2$. Therefore, ST is parallel to QR.

**e)** Answers may vary. For example: Use the length formula to show that each side of △PST is exactly half the length of the corresponding side of △PQR.

**16.** Answers may vary.
*The Geometer's Sketchpad®* example:
**a)** Construct the triangle with vertices P, Q, and R.
**b)** Construct the midpoint of PQ and of PR. Then, display the coordinates of the midpoints.
**c)** Measure and compare the lengths of ST and QR.
**d)** Measure and compare the slopes of ST and QR.
**e)** Measure and compare either the side lengths or the angles of △PQR and △STU, where U is the midpoint of QR.

Cabri® Jr. example:
**a)** Choose **Triangle** from the **F2** menu, and construct △PQR. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the vertices. Adjust the vertices if necessary.
**b)** Choose **Midpoint** from the **F3** menu, and construct the midpoint of PQ and of PR. Choose **Coord. & Eq.** from the **F5** menu, and select the midpoints.
**c)** Choose **Measure/D. & Length** from the **F5** menu. Then, select ST and QR.
**d)** Choose **Measure/Slope** from the **F5** menu. Then, select ST and QR.
**e)** Use the **Measure** options in the **F5** menu to compare either the side lengths or the angles of △PQR and △STU, where U is the midpoint of QR.

**17. a)** Edmonton–Ottawa 2851 km;
Montréal–Toronto 504 km;
Edmonton–Toronto 2710 km

**b)** Answers may vary. For example: The flying distances are about 2840 km for Edmonton–Ottawa, 505 km for Montréal–Toronto, and 2705 km for Edmonton–Toronto. The telephone coordinate system gives distances that are close to the flying distances.

**18. a)** $(1, 0), (2, 0), \left(1\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$

**b)** Yes. Explanations may vary. For example: The sides inserted in each step are similar to two sides in the original triangle and the angle at each new point of the snowflake is equal to the angles in the original triangle.

**20. a)** 2

**b)** Yes. Explanations may vary. For example: The equation $5 = \sqrt{(2 - x)^2 + (6 - 1)^2}$ simplifies to $(2 - x)^2 = 0$, so $x = 2$.

**21. a)** Answers may vary. For example: For the simplest solutions, locate one endpoint at the origin. Substituting $x_1 = 0$ and $y_1 = 0$ into the length formula then shows that the sum of the squares of the *x*- and *y*-coordinates of the other endpoint equals the square of the required length. Example endpoints are **i)** (1, 1) **ii)** (2, 1) **iii)** (3, 2) **iv)** (5, 4)

**22.** Answers may vary. **a)**(5, 0), (0, 5), (–5, 0), (0, –5)
**b)** (7, 1), (2, 6), (–3, 1), (2, –4)
**c)** (5, –2), (–5, 8), (–15, –2), (–5, –12)

**23.** (–2, 11); 11.2 m

**24.** A

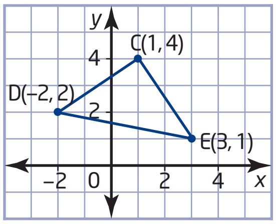
**25.** Answers may vary. For example: Substituting the Pythagorean relationship into the area formula for the large semicircle gives

$$\begin{aligned}\frac{1}{2}\pi a^2 &= \frac{1}{2}\pi(b^2 + c^2)\\ &= \frac{1}{2}\pi b^2 + \frac{1}{2}\pi c^2\end{aligned}$$

## 2.3 Apply Slope, Midpoint, and Length Formulas, pages 80–91

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

**2.** Answers may vary. For example: If the triangle has a right angle, the slopes of two of the sides are negative reciprocals of each other and the lengths of the sides are related by the Pythagorean theorem.

**3. a)** 


**b)** $m_{CD} \times m_{CE} = -1$

**4.** $\sqrt{13}$

**5. a)** $m_{MN} = m_{QR} = 2$ **b)** $MN = 2\sqrt{5} = \frac{1}{2}QR$

**6.** Answers may vary. For example: Any point on the right bisector of a line segment is equidistant from the endpoints of the segment. Applying the length formula shows that VT ≠ UT. Therefore, point T does not lie on the right bisector of UV.

**7. a)** $m_{OP} = m_{RQ} = \frac{5}{3}$ and $m_{PQ} = m_{OR} = \frac{1}{5}$. Therefore, opposite sides are parallel and OPQR is a parallelogram.

**b)** Answers may vary. For example: Use geometry software to construct OPQR and measure the slope of each side. These slopes show that the opposite sides are parallel.

**8. a)** (3, 6) **b)** $\sqrt{37}$

**9.** Since $AB = AC = 2\sqrt{40}$, △ABC is isosceles.

**10.** $\frac{9}{\sqrt{5}}$

**11.** $\frac{4}{\sqrt{5}}$

**12.** $\frac{\sqrt{32\,674}}{34}$

**13.** $\frac{30}{\sqrt{17}}$

**14.** $4\sqrt{5}$

**15.** Answers may vary.

*The Geometer's Sketchpad*® example:

**a)** Construct line segment AB and point R. Construct a perpendicular from point R to AB. Construct point D, the point of intersection of the perpendicular and AB. Display the coordinates of point D. Line segment RD represents the shortest route. Measure the length of RD, and multiply by 0.5 to find the length of the side road in kilometres.

**b)** Construct △ABC. Measure the angles or compare the slopes of the sides to determine that ∠ACB is a right angle.

**c)** Construct the midpoint, D, of side AB. Construct line segment CD. Measure and compare the lengths of AB and CD.

Cabri® Jr. example:

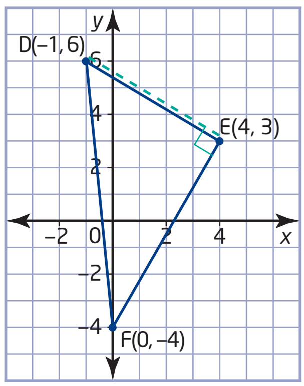
**a)** Choose **Segment** from the **F2** menu, and construct line segment AB. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the points. Adjust their positions if necessary. Choose **Point** from the **F2** menu, and construct point R. Choose **Perp.** from the **F3** menu, and construct the perpendicular from point R to AB. Choose **Coord. & Eq.** from the **F5** menu, and select point D, the point of intersection of the perpendicular and AB. Line segment RD represents the shortest route. Choose **Measure/D. & Length** from the **F5** menu, and select RD. Multiply the displayed length by 0.5 to find the length of the side road in kilometres.

**b)** Choose **Triangle** from the **F2** menu, and construct △ABC. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the vertices. Adjust the vertices if necessary. Choose **Measure** from the **F5** menu. Then, choose **Angle** and measure the angles of △ABC, or choose **Slope** and measure the slopes of the three sides. Both sets of measurements show that ∠ACB is a right angle.

**c)** Choose **Midpoint** from the **F3** menu, and select side AB. Choose **Segment** from the **F2** menu, and construct line segment CD. Choose **Measure/D. & Length** from the **F5** menu, and select AB and CD.

**16.** (6, 0). Methods may vary. For example: Find an equation for the line that is parallel to AB and passes through point C. Then, find an equation for the line that is parallel to BC and passes through point A. Vertex D is the point of intersection of these two lines. Alternative method: The run and rise from vertex B to vertex C are the same as those from vertex A to vertex D. Therefore, adding this run and rise to the coordinates of vertex A gives the coordinates of vertex D.

**17. a)** $y = -\frac{1}{2}x - 1$ **b)** $2\sqrt{5}$

**18. a)** 


**b)** $y = -\frac{4}{7}x + \frac{38}{7}$

**19.** Answers may vary.

*The Geometer's Sketchpad*® example:

**a)** Construct the triangle with vertices D, E, and F. Then, construct the perpendicular from D to EF.

**b)** Select the perpendicular and choose **Equation** from the **Measure** menu.

Cabri® Jr. example:

**a)** Choose **Triangle** from the **F2** menu, and construct △DEF. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the vertices. Adjust the vertices if necessary. Choose **Perp.** from the **F3** menu, and construct the perpendicular from D to EF.

**b)** Choose **Coord. & Eq.** from the **F5** menu, and select the perpendicular.

**20.** **a)** Since $m_{PQ} = m_{RS} = \frac{4}{3}$ and $m_{PS} = m_{QR} = -\frac{3}{4}$, each pair of adjacent sides is perpendicular.

**b)** PR = QS = $5\sqrt{5}$

**c)** The midpoint of both diagonals is $\left(\frac{1}{2}, 3\right)$.

**d)** The diagonals bisect each other.

**21.** **a)** $y = 2x - 8$ **b)** $\frac{26}{\sqrt{5}}$

**c)** 39 square units

**22.** Answers may vary.

*The Geometer's Sketchpad®* example:

**a)** Construct the triangle with vertices J, K, and L. Construct the perpendicular from L to JK. Construct point M, the point of intersection of the perpendicular and JK. Construct line segment LM. Select the perpendicular, and choose **Equation** from the **Measure** menu.

**b)** Measure the length of LM.

**c)** Select the interior of △JKL and choose **Area** from the **Measure** menu.

Cabri® Jr. example:

**a)** Choose **Triangle** from the **F2** menu, and construct △JKL. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the vertices. Adjust the vertices if necessary. Choose **Perp.** from the **F3** menu, and construct the perpendicular from L to JK. Choose **Measure/D. & Length** from the **F5** menu, and select the endpoints of the altitude.

**b)** Choose **Coord. & Eq.** from the **F5** menu, and select the perpendicular.

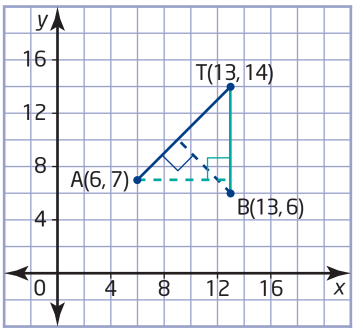
**c)** Choose **Measure/Area** from the **F5** menu, and select △JKL.

**23.** **a)** (10.8, 9.4) **b)** 85 m

**24.** **a)** (4.5, 6.5)

**b)** Answers may vary. For example: The shortest route might be blocked by fences or thick woods, or it might involve trespassing on private land.

**25.** **a)**




**b)** Connect the transformer to cottage B, and continue to cottage A.

**26.** Answers may vary.

*The Geometer's Sketchpad®* example:

**a)** Plot the points A, B, and T. Construct line segment AT and the perpendicular from AT to B. Construct point C where the perpendicular meets AT. Then, construct line segment BT and the perpendicular from BT to A. Construct point D where the perpendicular meets BT.

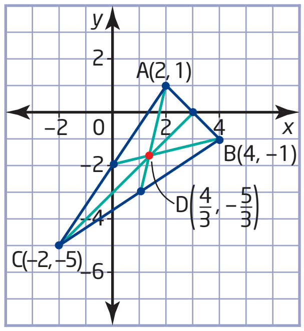
**b)** Measure the lengths of AT, BC, BT, and AD. Use these measurements to show that BT + AD is less than AT + BC.

Cabri® Jr. example:

**a)** Choose **Point** from the **F2** menu, and plot the points A, B, and T. Choose **Coord. & Eq.** from the **F5** menu, and display the coordinates of the points. Adjust the points if necessary. Choose **Segment** from the **F2** menu, and construct line segments AT and BT. Choose **Perp.** from the **F3** menu, and construct the perpendicular from B to AT. Label the point of intersection C. Similarly, construct the perpendicular from A to BT, and label the point of intersection D.

**b)** Choose **Measure/D. & Length** from the **F5** menu, and select AT, BC, BT, and AD. Use these measurements to show that BT + AD is less than AT + BC.

**28.** **a)**




**b)** Find the point of intersection of two of the medians. Then, verify that the coordinates of this point satisfy the equation for the third median. The centroid is $\left(\frac{4}{3}, -\frac{5}{3}\right)$.

**29.** The median to the hypotenuse of a right triangle is half as long as the hypotenuse. Methods may vary.

*The Geometer's Sketchpad®* example: Construct any line and a perpendicular to it. Construct point A where the perpendicular meets the line. Construct point B anywhere on the line and point C anywhere on the perpendicular. Construct line segment BC and the midpoint, D, of BC. Construct line segment AD. Measure and compare the lengths of AD and BC. Observe the ratio of these lengths while dragging point B along the line and point C along the perpendicular.

Cabri® Jr. example: Choose **Line** from the **F2** menu, and construct any line. Choose **Perp.** from the **F3** menu, and construct a line perpendicular to the first line. Choose **Point/Intersection** from the **F2** menu, and construct point A, the intersection of the two lines. Choose **Point/Point on**, and construct point B on the first line and point C on the second line. Choose **Segment** from the **F2** menu, and construct line segment BC. Choose **Midpoint** from the **F3** menu, and construct point D, the midpoint of BC. Construct line segment AD. Choose **Measure/D. & Length** from the **F5** menu, and select BC and AD. Move the cursor to point B, and press ALPHA. Observe the ratio of the lengths of BC and AD while sliding point B along the first line. Slide point C along the other line.

**30.** **a)** $\sqrt{41}$

**b)** $d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$

**31.** **a)** Use slopes to show that CE and DF are perpendicular to AB.

**b)** 144 m **c)** (75.5, 45) **d)** No. CD > CE + DF

**32.** A

**33.** C

## 2.4 Equation for a Circle, pages 92–99

**1.** **a)** $x^2 + y^2 = 9$ **b)** $x^2 + y^2 = 64$ **c)** $x^2 + y^2 = 100$ **d)** $x^2 + y^2 = 5$ **e)** $x^2 + y^2 = 12$ **f)** $x^2 + y^2 = 110$

**2.** **a)** 6; points on circle include (6, 0), (0, 6), (−6, 0), and (0, −6)

**b)** 12; points on circle include (12, 0), (0, 12, (−12, 0), and (0, −12)

**c)** $\sqrt{20}$; points on circle include (2, 4), (−2, 4), (−2, −4), (2, −4), (4, 2)

**d)** $\sqrt{50}$; points on circle include (5, 5), (5, −5), (−5, −5), (−5, 5)

**e)** 1.3; points on circle include (1.3, 0), (0, 1.3), (−1.3, 0), and (0, −1.3)

**3.** **a)** $x^2 + y^2 = 25$ **b)** $x^2 + y^2 = 29$ **c)** $x^2 + y^2 = 45$ **d)** $x^2 + y^2 = 193$

**4.** **a)** on **b)** inside **c)** outside **d)** on **e)** outside **f)** on

**5.** No.

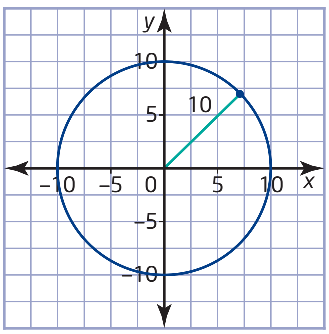
**6.** $x^2 + y^2 = 25$

**7.** **a)** Substituting the coordinates into the equation gives $a^2 = 36$. Therefore, $a$ can be either 6 or −6.

**b)** Graph the circle $x^2 + y^2 = 100$. The points (6, 8) and (−6, 8) are both on this circle.

**8.** **a)** 50.3 m **b)** 201 m$^2$

**9.** **a)**



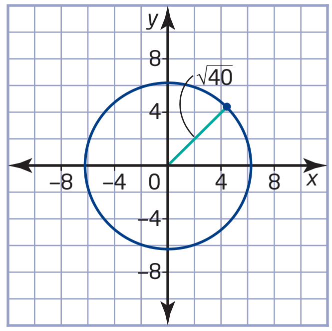

**b)** The coordinates (−8, 6) and (6, 8) both satisfy the equation of the circle.

**c)** $y = -7x$

**d)** The coordinates (0, 0) satisfy the equation $y = -7x$.

**e)** Answers may vary. For example: Since the endpoints of any chord lie on a circle, they are equidistant from the centre of the circle. All points equidistant from the endpoints of a line segment lie on the right bisector of the line segment. Therefore, the right bisector of any chord of a circle passes through the centre of the circle.

**10.** **a)**

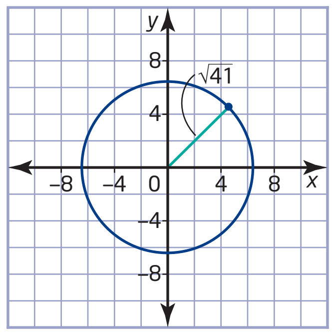



**b)** The coordinates of points R and S satisfy the equation of the circle.

**c)** $y = x$

**d)** Since $m_{OM} = 1$ and $m_{RS} = -1$, the line is perpendicular to RS.

**11.** **a)**



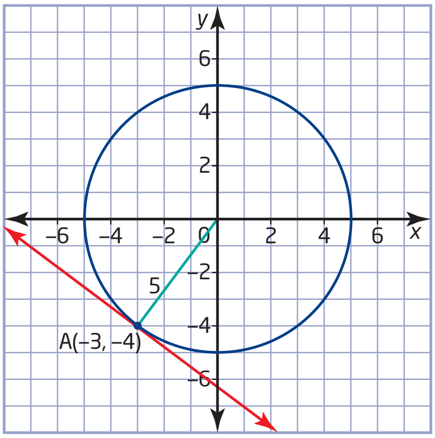

**b)** The coordinates of points U and V satisfy the equation of the circle.

**c)** $y = -\frac{1}{9}x$

**d)** The midpoint coordinates $\left(-4\frac{1}{2}, \frac{1}{2}\right)$ satisfy the equation $y = -\frac{1}{9}x$.

**12.** The right bisector of any chord of a circle passes through the centre of the circle. Methods may vary.
*The Geometer's Sketchpad*® example: Construct any circle and a line segment between two points on the circle. Construct the right bisector of the line segment. Choose **Animate Point** from the **Display** menu, and animate either endpoint of the line segment. Observe whether the right bisector continues to pass through the centre of the circle. Also, try varying the radius of the circle.
Cabri® Jr. example: Choose **Circle** from the **F2** menu, and construct any circle. Choose **Segment** from the **F2** menu, and construct any line segment with both endpoints on the circumference of the circle. Choose **Perp. Bis.** from the **F3** menu, and select the line segment. Move the cursor to either endpoint of the line segment, and press ALPHA. Drag the endpoint around the circumference of the circle and observe whether the right bisector continues to pass through the centre of the circle. Also, try varying the radius of the circle.

**13. a), c), d)**




**b)** The coordinates of point A satisfy the equation $x^2 + y^2 = 25$.

**e)** $y = -\frac{3}{4}x - \frac{25}{4}$

**f)** Answers may vary. For example: The tangent touches the circle at point A. Since the circle curves away from the tangent on both sides of point A, the tangent does not touch the circle at any other point.

**14.** Answers may vary. For example: The point that is equidistant from the three homes is the centre of the circle that passes through all three homes. A line segment joining any two of the homes is a chord of the circle. The point of intersection of the right bisectors of two of these chords is the centre of the circle. Brandon could draw these right bisectors on a city map and then look for a restaurant near the point where they intersect.

**15.** Yes.

**16.** The blocks will not fit in the smallest cup.

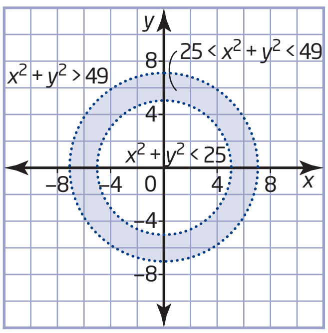
**17. a)** $x^2 + y^2 = 250\ 000$ **b)** 180 s

**c)** Answers may vary. For example: Wind or water currents do not move the rowboat or change the shape or speed of the ripple as it travels.

**18. a)** the region inside the circle centred at (0, 0) with radius 5

**b)** the region outside the circle centred at (0, 0) with radius 7

**c)** the region between the circle centred at (0, 0) with radius 5 and the circle centred at (0, 0) with radius 7




**19.** $x^2 + y^2 = 8$

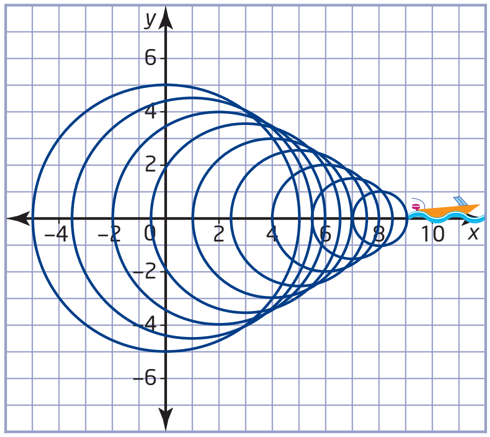
**20. a)** $x^2 + y^2 = 16$ **b)** B(0, 2), D(2, 0)

**c)** AB, $y = -\frac{1}{2}x + 2$; CD, $y = -2x + 4$

**d)** $\left(\frac{4}{3}, \frac{4}{3}\right)$ **e)** $4\pi - \frac{16}{3}$, or about 7.2 square units

**21. a)** 5 m

**b)**

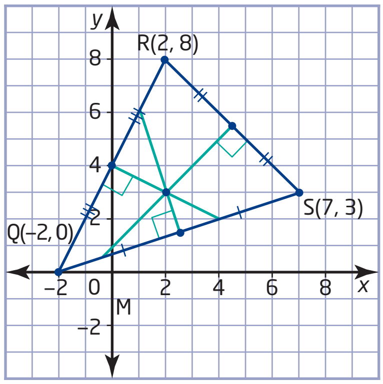



**c)** At the points of intersection, the waves add together to form a V-shaped wake behind the boat.

**22.** $(x - 4)^2 + (y - 3)^2 = 25$

**23.** Answers may vary. For example: No circle with $1 < r < 2$ has any points for which both the $x$- and $y$-coordinates are integers.

**24. a)**




**b)** The coordinates (2, 3) satisfy the equations of all three of the right bisectors.

**c)** QC = RC = SC = 5

**d)** The circle has radius 5 and centre (2, 3).

**e)** Answers may vary.
*The Geometer's Sketchpad®* example: Construct △QRS and the right bisector of each side. Construct the point of intersection of the right bisectors and confirm that all three intersect at the same point. Measure the distance from each vertex to the point of intersection of the right bisectors. The distance in part c) is the radius of the circle. Display the coordinates of the point of intersection, which is the centre of the circle.
Cabri® Jr. example: Choose **Triangle** from the **F2** menu, and construct △QRS. Choose **Coord. & Eq.** from the **F5** menu, and check the placement of the vertices. Adjust the vertices if necessary. Choose **Perp. Bis.** from the **F3** menu, and select each side of △QRS. Choose **Point/Intersection** from the **F2** menu, and select the three right bisectors. Choose **Measure/D. & Length** from the **F5** menu, and measure the distance from each vertex to the point of intersection of the right bisectors. The distance in part c) is the radius of the circle. Choose **Coord. & Eq.** from the **F5** menu, and select the point of intersection to display the coordinates of the centre of the circle.

25. $\dfrac{r}{\sqrt{k}}$

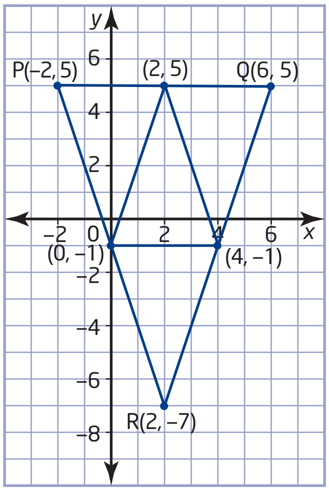
26. **a)** ellipse (a type of oval) with its length along the *x*-axis
**b)** ellipse with its length along the *y*-axis

### Chapter 2 Review, pages 100–103

1. **a)** $(1, 2)$ **b)** $(1.5, 2)$
**c)** $(2.5, 4)$ **d)** $(148, 231)$

2. **a)** $(-1, -5.5)$ **b)** $(4, 3)$

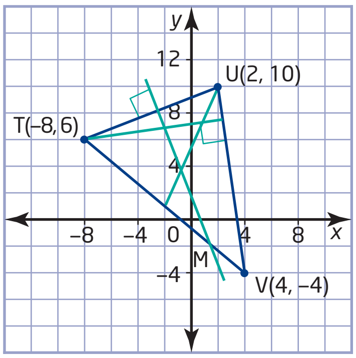
3. **a), c)**




**b)** $(2, 5)$, $(4, -1)$, and $(0, -1)$

**c)** The smaller triangle is similar to △PQR and has $\frac{1}{4}$ the area.

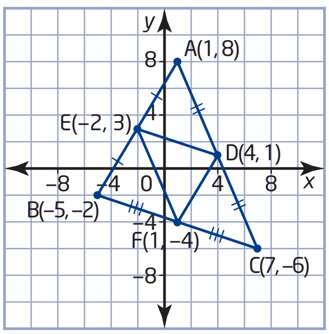
4. **a)**




**b)** $y = \frac{9}{4}x + \frac{11}{2}$ **c)** $y = \frac{1}{7}x + \frac{50}{7}$

**d)** $y = -\frac{5}{2}x + \frac{1}{2}$

5. **a)**




**b)** $(1, 8)$, $(-5, -2)$, $(7, -6)$

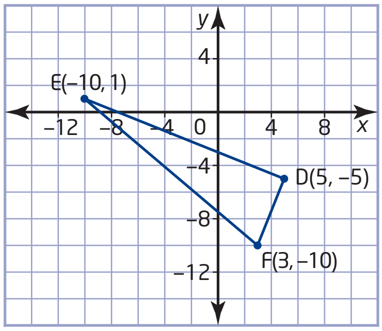
**c)** Answers may vary.
*The Geometer's Sketchpad*® example: Plot points D, E, and F. Construct line segments DE, EF, and DF. Construct a line through D parallel to EF, a line through E parallel to DF, and a line through F parallel to DE. Construct the points of intersection and display their coordinates.
Cabri® Jr. example: Choose **Point** from the **F2** menu, and construct △DEF. Choose **Coord. & Eq.** from the **F5** menu, and check the placement of the midpoints. Adjust the placement if necessary. Choose **Segment** from the **F2** menu, and construct line segments DE, EF, and DF. Choose **Parallel** from the **F3** menu, and construct a line through D parallel to EF, a line through E parallel to DF, and a line through F parallel to DE. Choose **Point/Intersection** from the **F2** menu, and construct the three points of intersection of the lines. Choose **Coord. & Eq.** from the **F5** menu, and select the points of intersection.

6. **a)** 13 **b)** 10 **c)** $\sqrt{106}$ **d)** $12\frac{1}{2}$

7. **a)** 10 **b)** 13 **c)** $\sqrt{128}$
**d)** $\sqrt{61}$ **e)** 9 **f)** $\sqrt{65}$

8. **a)** $\sqrt{\dfrac{325}{4}}$ **b)** $\sqrt{117} + \sqrt{73} + \sqrt{82}$, or about 28.4

9. **a)**




**b)** right triangle **c)** $43\frac{1}{2}$ square units

**d)** Answers may vary.
*The Geometer's Sketchpad*® example: Construct △DEF. Measure the angles and side lengths. Select the interior of △DEF, and choose **Area** from the **Measure** menu.
Cabri® Jr. example: Choose **Triangle** from the **F2** menu, and construct △DEF. Choose **Coord. & Eq.** from the **F5** menu, and check the placement of the midpoints. Adjust the vertices if necessary. Choose **Measure/D. & Length** from the **F5** menu, and select the sides of △DEF. Choose **Measure/Angle**, and select the angles of △DEF. Choose **Measure/Area**, and select △DEF.

10. AC = BC = 5

11. **a)** $m_{DE} = \frac{5}{2}$ and $m_{EF} = -\frac{2}{5}$; therefore, $\angle$ DEF = 90°.

**b)** $\left(2, 2\frac{1}{2}\right)$

**c)** The distance from the midpoint to each vertex is $\sqrt{\dfrac{145}{4}}$.

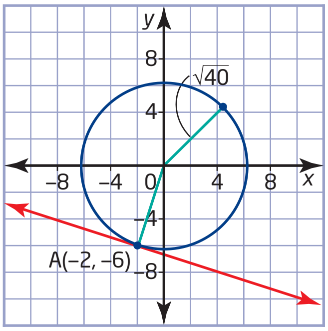
12. **a)** 28.3 km **b)** (55, 50)
**c)** No, the coordinates (63, 54) do not satisfy the equation $y = x - 5$.
**d)** From point C, run a straight pipe that meets the main pipeline at a right angle at (57, 48).

13. $\sqrt{10}$

14. **a)** $x^2 + y^2 = 16$ **b)** $x^2 + y^2 = 34$ **c)** $x^2 + y^2 = 29.16$

15. **a)** $x^2 + y^2 = \frac{81}{4}$ **b)** $x^2 + y^2 = 49$
**c)** $x^2 + y^2 = 12$ **d)** $x^2 + y^2 = 65$

16. **a)** Point A lies on the circle.
**b)** $y = 3x$
**c)** $y = -\frac{1}{3}x - \frac{20}{3}$
**d)**




**e)** Answers may vary. For example: On either side of point A, the circle curves away from the tangent line.

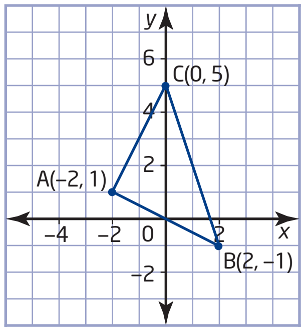
17. **a)** Since both (−3, 1) and (1, 3) satisfy the equation $x^2 + y^2 = 10$, the line segment connecting them is a chord of the circle.
**b)** $y = -2x$
**c)** Since (0, 0) satisfies the equation $y = -2x$, the line passes through the centre of the circle.

18. Yes.

## Chapter 2 Practice Test, pages 104–105

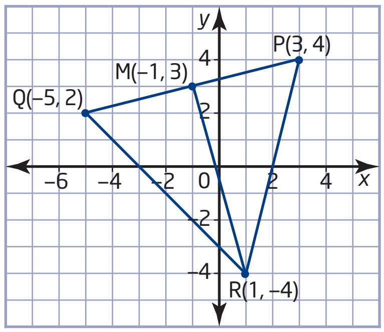
1. C
2. C
3. D
4. EF: midpoint $\left(-3, -\frac{1}{2}\right)$, length 7; GH: midpoint (1, 4), length 4; IJ: midpoint $\left(\frac{1}{2}, -2\frac{1}{2}\right)$, length $\sqrt{74}$; KL: midpoint $\left(5, -3\frac{1}{2}\right)$, length $\sqrt{13}$
5. **a)** $x^2 + y^2 = 36$
**b)** $x^2 + y^2 = 18$
6. Answers may vary. For example: No, any point on the right bisector of BC is equidistant from points B and C.
7. **a)** 11.2 km
**b)** (9, 5.5)
**c)** Answers may vary. For example: Any point on the perpendicular bisector of PS will be equidistant from the two schools.
**d)** $y = -2x + 23\frac{1}{2}$

8. **a)**




**b)** $AB = AC = \sqrt{20}$, $BC = \sqrt{40}$
**c)** $AB = AC \neq BC$. Since $m_{AC} = 2$ and $m_{AB} = -\frac{1}{2}$, AB is perpendicular to AC. Therefore, △ABC is an isosceles right triangle.
**d)** 10 square units
**e)** Answers may vary.
*The Geometer's Sketchpad*® example: Construct △ABC. Measure each side. Compare the lengths of the sides and the measures of the angles. Select the interior of △ABC, and choose **Area** from the **Measure** menu.
Cabri® Jr. example: Choose **Triangle** from the **F2** menu, and construct △ABC. Choose **Coord. & Eq.** from the **F5** menu, check the placement of the vertices, and adjust them if necessary. Choose **Measure/D. & Length** from the **F5** menu, and select the sides of △ABC. Compare the lengths of the sides. Choose **Measure/Angle**, and select the angles of △ABC. Choose **Measure/Area**, and select △ABC.

9. **a)**




**b)** $y = -\frac{7}{2}x - \frac{1}{2}$
**c)** No. Explanations may vary. For example: The slope of PQ is not the negative reciprocal of the slope of the median. Therefore, the median is not perpendicular to PQ and is not an altitude of the triangle.

10. **a)** (−3, 5) **b)** Yes, (3, 5) also lies on the circle.
**c)** $x^2 + y^2 = 34$
**d)** Substitute the coordinates (3, 5) into the equation $x^2 + y^2 = 34$ to see if they satisfy the equation.
**e)** Answers may vary. For example: (−3, −5), (−5, 3), (5, 3), $(0, \sqrt{34})$

11. **a)** G(3, 8); H(6, 4)
**b)** $m_{GH} = m_{DE} = -\frac{4}{3}$; therefore, GH is parallel to DE.
**c)** Applying the length formula gives GH = 5 and DE = 10.

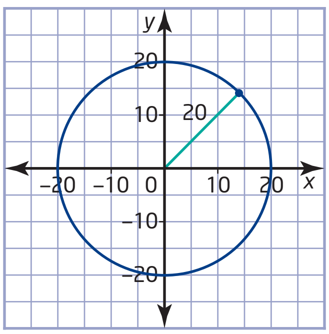
**12. a)** Answers may vary. For example: Since $m_{UV} = 2$ and $m_{WV} = -\frac{1}{2}$, $\angle WVU = 90°$.

**b)** Use the length formula to show that the length of the median is 5 and the length of the hypotenuse is 10.

**c)** $x^2 + y^2 = 25$

**d)** Answers may vary.
*The Geometer's Sketchpad*® example: Construct △UVW, and measure each angle. Construct the midpoint, M, of side UW. Construct line segment VM. Measure the length of UW and of VM. Construct the circle with centre M and radius 5. Select the circle and choose **Equation** from the **Measure** menu.
Cabri® Jr. example: Choose **Triangle** from the **F2** menu, and construct △UVW. Choose **Coord. & Eq.** from the **F5** menu, check the placement of the vertices, and adjust them if necessary. Choose **Measure/Angle** from the **F5** menu, and select the angles of △UVW. Choose **Midpoint** from the **F3** menu, and construct the midpoint, M, of side UW. Choose **Segment** from the **F2** menu, and select points V and M. Choose **Measure/D. & Length** from the **F5** menu, and select UW and VM. Choose **Circle** from the **F2** menu, and construct the circle with centre M and radius 5. Choose **Coord. & Eq.** from the **F5** menu and select the circle.

**13. a)**




**b)** $x^2 + y^2 = 400$

**c)** No, Diane is 20.4 km away from the office.

**d)** Yes, Diane and Arif are only 12.6 km apart.

# Chapter 3

## Get Ready, pages 108–109

**1. a)** $\left(1\frac{1}{2}, 1\frac{1}{2}\right)$ **b)** $(1, -1)$ **c)** $\left(4, 1\frac{1}{2}\right)$ **d)** $(-3, 5)$

**2. a)** $\sqrt{74}$ **b)** $\sqrt{53}$ **c)** 9 **d)** 10

**3. a)** $(3, -1)$ **b)** $(-1, 3)$ **c)** $(2, -1)$

**4. a)** $(-1, -2)$ **b)** $(4, -3)$ **c)** $(-2, -1)$

**5. a)** $\angle D = 55°$ **b)** $\angle G = 30°$

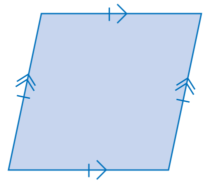
**6. a)** $\angle J = \angle K = 70°$ **b)** $\angle P = 80°$, $\angle R = 50°$

**7. a)** A rectangle has four sides and four right angles.

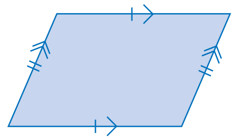
**b)** A parallelogram is a quadrilateral with opposite sides parallel.

**c)** A trapezoid is a quadrilateral with two sides parallel.

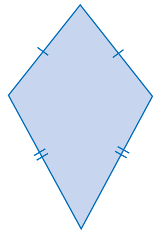
**8. a)**



**b)**



**c)**



## 3.1 Investigate Properties of Triangles, pages 110–116

**1.** 6 square units

**2.** 60 square units

**3. a)** JL and KM

**b)** $\angle MJK = \angle MLK$, $\angle JMK = \angle LMK$, and $\angle JKM = \angle LKM$

**4.** the bisector of ∠R, the altitude from vertex R, and the right bisector of side PQ

**5. a)** Answers will vary.

**b)** In an isosceles triangle, the altitude from the vertex between the equal sides bisects the angle at the vertex, bisects the opposite side, and coincides with the median from the vertex.

**c)** Use compasses or a ruler and protractor to verify that the altitude bisects the opposite side and the angle at the vertex.

**6.** No. Explanations may vary. For example: The triangle could be isosceles since the median from the vertex between the equal sides is also an angle bisector.

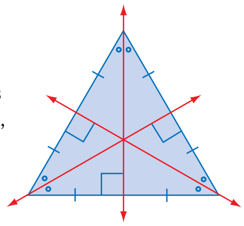
**7. a)** Answers will vary.

**b)** The distances are equal.

**c)** The relationship applies to all right triangles. Methods may vary. For example: Let A(0, 0), B($x$, 0), and C(0, $y$) be the vertices of a right triangle. Find the coordinates of M, the midpoint of the hypotenuse BC. Substitute into the length formula to get expressions for the lengths of AM, BM, and CM. Alternatively, use geometry software to construct two perpendicular lines and their point of intersection. Construct another point on each line. Then, form a right triangle by constructing line segments joining the three points. Construct the midpoint of the hypotenuse. Measure the distance from the midpoint to each vertex. Compare these distances while dragging the vertices of the triangle along the perpendicular lines.

**8.** Answers may vary. For example: Each median bisects the angle at a vertex. Each median is perpendicular to the opposite side. Each altitude bisects a side. The medians are equal in length. The altitudes are equal in length. Each right bisector of a side passes through a vertex and bisects the angle at the vertex. Congruent triangles or geometry software can be used to show that these properties apply for all equilateral triangles.

**9.** Alana is correct. Explanations may vary. For example: In an equilateral triangle, the angle bisectors and the right bisectors of the sides coincide. Therefore, the point of intersection of the angle bisectors is also the point of intersection of the right bisectors (the circumcentre and the incentre coincide).



**10. a)** The medians are divided in a 2:1 ratio.

**b)** Answers may vary. For example: Draw at least one example of each type of triangle, and measure how the centroid divides all three medians in each triangle. Alternatively, use geometry software to construct a triangle and its medians. Measure from the centroid to either end of each median. Compare these measurements while dragging the vertices of the triangle.

**c)** Draw any median. The balance point is on the median two thirds of the way from the vertex to the opposite side.

**11. a)** Answers will vary.

**b)** The slopes are equal and DE is half the length of BC.

**c)** The relationships apply for any triangle. Methods may vary. For example: Draw at least one example of each type of triangle. In each triangle, compare the slope and length of the line segment joining the midpoints of two sides to those of the third side. Alternatively, use geometry software to construct a triangle and the line segment joining the midpoints of two sides. Measure the slope and length of this segment and of the third side. Compare these measurements while dragging the vertices of the triangle.

**12. a)** Yes.

**b)** Yes. Explanations may vary. For example: Angle bisectors drawn in examples of each type of triangle meet at a point in each triangle.

**c)** The incentre is the centre of the circle that just touches each side of the triangle.

**d)** The incentre is equidistant from each side of the triangle. Explanations may vary. For example: In examples of each type of triangle, a circle that is centred at the incentre and just touches one side of the triangle also just touches the other two sides.

**13.** Answers may vary. For example: Construct any triangle and the bisector of each of its angles. Observe the point of intersection of the three angle bisectors while dragging the vertices of the triangle. Measure the perpendicular distance from the point of intersection to each side. Compare these distances while dragging the vertices of the triangle. The angle bisectors always meet at a single point, which is equidistant from the sides of the triangle.

**14. a)** Every triangle has a circumcentre. Methods may vary. For example: Draw the right bisectors of the sides in at least one example of each type of triangle. Alternatively, use geometry software to construct a triangle and the right bisectors of its sides. Observe the point of intersection of the right bisectors while dragging the vertices of the triangle.

**b)** The circumcentre is equidistant from the vertices. Explanations may vary. For example: The distances from the circumcentre to the vertices are equal in examples of each type of triangle. Alternatively, for a triangle constructed with geometry software, the distances remain equal when the vertices are dragged.

**c)** On a map, draw a triangle with Hamilton, Oshawa, and Barrie at the vertices. Then, find the point of intersection of the right bisectors of the sides of the triangle.

**15.** The altitudes of any triangle meet at a single point. Methods may vary. For example: Draw the altitudes in at least one example of each type of triangle. Alternatively, use geometry software to construct the altitudes of a triangle, and observe their point of intersection while dragging the vertices of the triangle.

**16.** Answers will vary.

**17. a)** The area of the equilateral triangle on the hypotenuse equals the sum of the areas of the equilateral triangles on the other two sides. Methods may vary. For example: Use the Pythagorean theorem to find an expression for the height of each equilateral triangle. Write an expression for the area of each triangle, and use the Pythagorean theorem to show how the areas are related.

**b)** Answers will vary. For example: Use geometry software to construct two perpendicular lines and their point of intersection. Construct another point on each line. Then, form a right triangle by constructing line segments joining the three points. Construct an equilateral triangle on each side. Measure the area of each equilateral triangle, and calculate the sum of the areas of the triangles on the two shorter sides. Compare this sum to the area of the triangle on the hypotenuse while dragging the vertices of the right triangle along the perpendicular lines.

**18. a)** $x = 72°$, $y = 36°$ **c)** about 1.62

**d)** The ratio of the sides equals $\varphi$.

**e)** Yes.

**f)** Yes. The ratio of the sides equals $\varphi$.

**g)** No.

**19.** Yes. Explanations may vary. For example: The incentre is the centre of the circle that just touches each side of the triangle (see question 12). Since this circle is inside the triangle, its centre also lies inside the triangle.

**20. a)** when the triangle is obtuse

**b)** when the triangle is a right triangle

**21.** The centroid, orthocentre, and circumcentre of a triangle are collinear. Methods may vary. For example: Draw the medians, altitudes, and right bisectors of the sides in at least one example of each type of triangle. Then, check that a line can be drawn through the centroid, orthocentre, and circumcentre. Alternatively, use geometry software to construct a triangle and its centroid, orthocentre, and circumcentre. Construct a line through the centroid, orthocentre, and circumcentre. Drag the vertices of the triangle, and note whether the line continues to pass through all three centres.

**22. a)** when the triangle is obtuse

**b)** when the triangle is a right triangle

Methods may vary. For example: Find the orthocentre in several examples of each type of triangle.

**23.** Answers may vary. For example: Use similar triangles to show that each median of $\triangle ABC$ passes through the midpoint of a side of $\triangle DEF$.

### 3.2 Verify Properties of Triangles, pages 117–127

**1.** **a)** $y = \frac{1}{3}x + \frac{4}{3}$ **b)** $y = -\frac{1}{5}x + \frac{11}{5}$ **c)** $x = 2$

**2.** **a)** $m_{DE} = m_{BC} = -\frac{2}{5}$

**b)** EF is parallel to AB, and DF is parallel to AC.

**c)** DE = BF = $\sqrt{29}$

**d)** DE = BF = FC, EF = AD = DB, DF = AE = EC

**3.** PQ = $2\sqrt{34}$, ST = $\sqrt{34}$

**4.** **a)** AB = BC = $2\sqrt{13}$

**b)** The slope of the median is the negative reciprocal of the slope of AC.

**c)** 8

**5.** Answers may vary. For example:

**a)** Construct △ABC. Measure and compare the lengths of AB, AC, and BC.

**b)** Construct the midpoint, D, of side AC. Construct line segment BD. Measure ∠ADB.

**6.** **a)** DE = $\sqrt{80}$, EF = DF = $\sqrt{40}$

**b)** $m_{DE} = 2$, $m_{EF} = \frac{1}{3}$, $m_{DF} = -3$

**c)** Since $m_{EF} \times m_{DF} = -1$ and EF = DF, △DEF is an isosceles right triangle.

**7.** **a)** scalene right triangle

**b)** JK = $\sqrt{338}$, KL = $\sqrt{104}$, JL = $\sqrt{234}$, and $m_{JL} \times m_{KL} = -1$.

**c)** $\sqrt{338} + \sqrt{104} + \sqrt{234}$, or about 43.9

**d)** 78 square units

**8.** Answers may vary. For example:

**a)** Construct △JKL.

**b)** Measure and compare the lengths and slopes of the three sides.

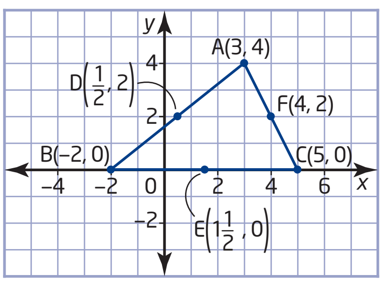
**c)** Calculate the sum of the lengths of the sides.

**d)** Measure the area of △JKL.

**9.** **b)** S(−10, 0), T(−4, 3) **c)** $m_{ST} = m_{RQ} = \frac{1}{2}$

**d)** ST = $3\sqrt{5}$, QR = $6\sqrt{5}$

**10.** **a)**




**b)** $\frac{ED}{AC} = \frac{EF}{AB} = \frac{FD}{BC} = \frac{1}{2}$

**c)** The area of △ABC is 14 square units, and the area of △DEF is 3.5 square units.

**d)** The ratio of the areas is the square of the ratio of the lengths of corresponding sides.

**11.** Answers may vary. For example:

**a)** Construct △ABC and the midpoints of its sides. Display the coordinates of the points.

**b)** Measure and compare the lengths of the corresponding sides.

**c)** Measure and compare the areas of △ABC and △DEF.

**d)** Calculate and compare the ratio of the side lengths and the ratio of the areas.

**12.** **a)** The medians intersect at (4, 4).

**b)** The stress on the support is minimized since the centroid is the balance point of the canopy.

**13.** **a)** JK = KL = 5, $m_{JK} \times m_{KL} = -1$

**b)** Since $JK^2 + KL^2 = JL^2$, △JKL is a right triangle. Since JK = KL = 5, △JKL is also isosceles.

**14.** **a)** $x = 4$, $y = -x + 4$, $y = x - 4$

**b)** (4, 0)

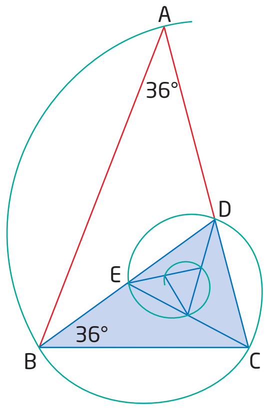
**c)** isosceles right triangle since OA = AB = $\sqrt{32}$ and $m_{OA} \times m_{AB} = -1$

**d)** the midpoint, (4, 0), of the hypotenuse

**15.** **a)** The coordinates (−4, 4) satisfy the equations of all three right bisectors.

**b)** CD = CE = CF = $\sqrt{260}$

**16.** **a), c), d)**




**b)** In both triangles, the ratio of the unequal sides is $\frac{1 + \sqrt{5}}{2}$, or about 1.618. △ABC and △BCD are similar because the corresponding angles are equal.

**e)** Yes, the curve in each step is similar to and smaller than the curve in the preceding step.

**18.** **a)** S$\left(\frac{a + c}{2}, \frac{b + d}{2}\right)$, T$\left(\frac{a + e}{2}, \frac{b + f}{2}\right)$

**b)** $m_{ST} = m_{QR} = \frac{f - d}{e - c}$

**c)** ST = $\frac{1}{2}\sqrt{(e - c)^2 + (f - d)^2}$,

QR = $\sqrt{(e - c)^2 + (f - d)^2}$

**19.** **a)** Answers will vary.

**b)** Since each median joins a vertex to the midpoint of the opposite sides, AD = DB, BE = EC, CF = FA, and $\frac{AD}{DB} \times \frac{BE}{EC} \times \frac{CF}{FA} = 1$.

**c)** Answers may vary. For example: Construct any △ABC and cevians from vertices A and B. Construct the point of intersection of the two cevians. Construct a line segment from vertex C through the point of intersection to side AB. Measure AD, DB, BE, EC, CF, and FA. Calculate $\frac{AD}{DB} \times \frac{BE}{EC} \times \frac{CF}{FA}$, and observe the value of this expression while dragging the vertices A, B, and C.

20. All of the triangles within the pentagon are golden triangles with either two 36° angles and one 108° angle or two 72° angles and one 36° angle.

21. Answers may vary. For example:

$$\begin{aligned}\textbf{L.S.} &= \varphi^2 \\ &= \left(\frac{1+\sqrt{5}}{2}\right)^2 \\ &= \frac{1+2\sqrt{5}+5}{4} \\ &= \frac{6+2\sqrt{5}}{4} \\ &= \frac{3+\sqrt{5}}{2}\end{aligned} \qquad \begin{aligned}\textbf{R.S.} &= \varphi + 1 \\ &= \frac{1+\sqrt{5}}{2} + 1 \\ &= \frac{1+\sqrt{5}+2}{2} \\ &= \frac{3+\sqrt{5}}{2}\end{aligned}$$

$$\textbf{L.S.} = \textbf{R.S.}$$

22. C

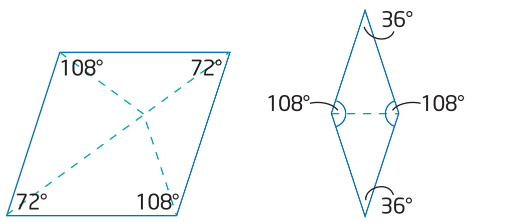
### 3.3 Investigate Properties of Quadrilaterals, pages 128–136

1. **a)** AE = CE, BE = DE **b)** PT = RT, QT = ST
2. **a)** EF is parallel to HG and EH is parallel to FG.
 **b)** TU is parallel to WV and TW is parallel to UV.
3. **a)** EF = HG, EH = FG **b)** TU = WV, TW = UV
4. **a)** AD, EG, and BC are parallel.
 **b)** 10
5. 9
6. Answers may vary. For example: The diagonals of a square bisect one another and are perpendicular. The diagonals also bisect the angles at the vertices.
7. Answers may vary. For example: Use parallel lines to construct a parallelogram. Measure the lengths of the diagonals. Compare these lengths while dragging the vertices. When the diagonals are equal in length, measure and compare the vertex angles.
8. **a)** Rhombus. Explanations may vary. For example: Since AC and BD bisect each other at right angles, quadrilateral ABCD contains four congruent triangles (side-angle-side). Therefore, the sides of the quadrilateral are all equal in length.
 **b)** Rectangle. Explanations may vary. For example: Since △AEH and △EBF are both isosceles, $\angle A + 2\angle AEH = 180°$ and $\angle B + 2\angle BEF = 180°$. So, $\angle A + \angle B + 2\angle AEH + 2\angle BEF = 360°$. Since $\angle A$ and $\angle B$ are co-interior angles, $\angle A + \angle B = 180°$. Substituting into the preceding equation gives $\angle AEH + \angle BEF = 90°$. The interior angles at E sum to 180°, so $\angle FEH = 90°$. Similarly, $\angle EFG = \angle FGH = \angle GHE = 90°$.
9. Answers may vary. For example: Rectangular shapes are easy to make, measure, store, and fit together.
10. No, the quadrilateral could also be a rectangle.
11. Answers may vary. For example:
 **a)** The diagonals of a rectangle are equal in length and bisect each other.
 **b)** The diagonals of a kite are perpendicular and the diagonal joining the vertices between the equal sides bisects the other diagonal.
 **c)** The diagonals bisect each other and are perpendicular.
 **d)** ...

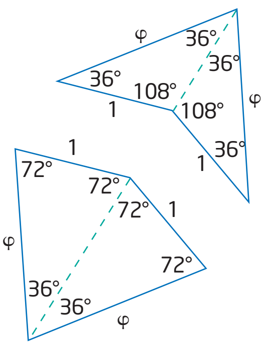
**e)**

| Shape | Equal Lengths | Perpendicular | Bisect Each Other | Bisect Vertex Angles |
|---|---|---|---|---|
| square | yes | yes | yes | yes |
| rectangle | yes | no | yes | no |
| parallelogram | no | no | yes | no |
| rhombus | no | yes | yes | yes |
| kite | no | yes | one | yes |

12. Answers may vary. For example:
 **a)** The balance point is at the point of intersection of the diagonals.
 **b)** Find the balance point of a cardboard rectangle.
13. Answers will vary.
15. **a)** when the quadrilateral is a kite or rhombus
 **b)** when the quadrilateral is a square
 **c)** when the quadrilateral is a rectangle
 **d)** Answers may vary. For example: Draw a rhombus. Draw the diagonals. Measure the length of the line segments that the diagonals cut each other into. Measure the angle between the two diagonals.
16. **a)** Yes. Explanations may vary. For example: The point of intersection of the diagonals of a rectangle is equidistant from the vertices.
 **b)** No. Diagrams will vary.
17. Answers may vary. For example: If the fastenings at the corners of a rectangular brace loosen, the brace can shift to a parallelogram shape. The shape of a triangular brace cannot change without bending or separating the sides.
18. **b)** The wide Penrose rhombus is made up of two pairs of golden triangles, and the narrow Penrose rhombus is made up of two congruent golden triangles.




 **c)** Aperiodic tiles can completely cover an infinite plane without any regular repetition of any sequence of the tiles.
 **d)** Answers may vary. For example: Every finite portion of any Penrose tiling is contained infinitely often in every other tiling.
 **e)** The lengths of the sides of both the Penrose dart and the Penrose kite are related by the golden ratio, and each shape can be divided into two golden triangles.




 **f)** Answers will vary.

**19.** Answers may vary. For example:

$$\textbf{L.S.} = \frac{1}{\varphi} = \frac{2}{1+\sqrt{5}} = \frac{2}{1+\sqrt{5}} \times \frac{1-\sqrt{5}}{1-\sqrt{5}} = \frac{2-2\sqrt{5}}{1-5} = \frac{2-2\sqrt{5}}{-4} = \frac{-1+\sqrt{5}}{2}$$

$$\textbf{R.S.} = \varphi - 1 = \frac{1+\sqrt{5}}{2} - 1 = \frac{1+\sqrt{5}}{2} - \frac{2}{2} = \frac{-1+\sqrt{5}}{2}$$

**L.S. = R.S.**

### 3.4 Verify Properties of Quadrilaterals, pages 137–144

**1.** $m_{AD} = m_{BC} = \frac{1}{3}$

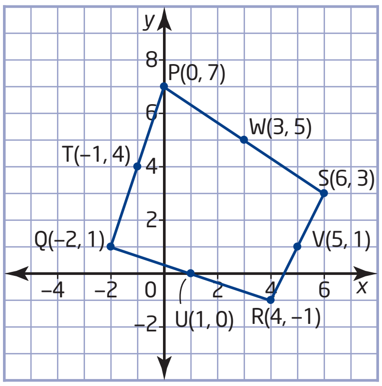
**2.** EF = FG = GH = EH = 5

**3.** JK = KL = $\sqrt{10}$, JM = LM = 5

**4. a)** Since $m_{AB} = m_{CD} = \frac{2}{3}$ and $m_{BC} = m_{AD} = -\frac{3}{2}$, all adjacent sides are perpendicular.

**b)** AC = BD = $\sqrt{65}$, and $\left(-\frac{1}{2}, -2\right)$ is the midpoint of both AC and BD.

**5. a), b)**




**c)** $m_{TU} = m_{WV} = -2$, $m_{UV} = m_{TW} = \frac{1}{4}$

**d)** TU = WV = $2\sqrt{5}$, UV = TW = $\sqrt{17}$

**6.** Answers may vary. For example:

**a)** Construct quadrilateral PQRS.

**b)** Construct the midpoint of each side and display the coordinates. Construct line segments joining adjacent midpoints.

**c)** Measure and compare the slopes of the sides of TUVW.

**d)** Measure and compare the lengths of the sides of TUVW.

**7. b)** $m_{AD} = m_{BC} = m_{EF} = \frac{3}{2}$, where E and F are the midpoints of AB and CD, respectively.

**8.** Answers may vary. For example: Construct trapezoid ABCD and midpoints E and F of AB and CD, respectively. Construct line segment EF. Measure and compare the slopes of AD, BC, and EF.

**9. a)** (1, 0) is the midpoint of both of JL and MK; $m_{JL} \times m_{MK} = -1$.

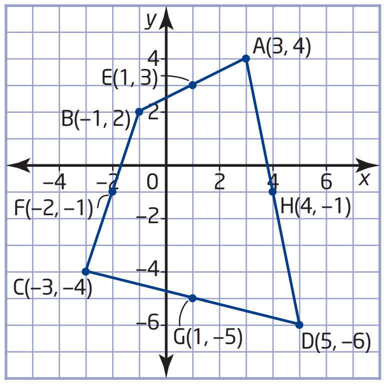
**b)** No.

**c)** The lengths of the sides are equal since the four small triangles formed by the diagonals are all congruent (side-angle-side).

**10. a)** QT = TS, $m_{PR} \times m_{QS} = -1$

**b)** PT ≠ RT

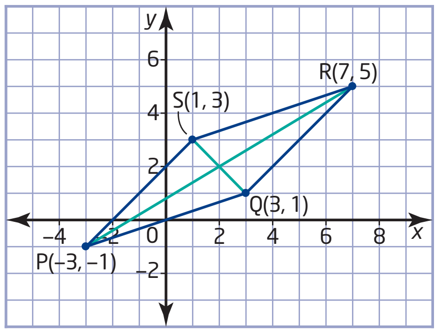
**11. a)**




**b)** EF = FG = GH = EH = 5

**c)** Answers may vary. For example: Use the length formula to show that two adjacent sides have equal lengths. Since EFGH is a Varignon parallelogram, its opposite sides are equal in length. Therefore, all four sides have equal lengths.

**12. a)**




**b)** (2, 2) is the midpoint of both PR and SQ.

**c)** PQRS is a parallelogram since $m_{PS} = m_{QR} = 1$ and $m_{SR} = m_{PQ} = \frac{1}{3}$.

**13.** Answers may vary. For example:

**a)** Construct quadrilateral PQRS, the diagonals PR and QS, and their point of intersection, T.

**b)** Measure and compare the lengths of PT, QT, RT, and ST.

**c)** Measure and compare the slopes and lengths of PQ, QR, RS, and SP.

**14. b)** The slopes of the adjacent sides are negative reciprocals.

**15.** Answers may vary. For example:
**a)** Construct quadrilateral ABCD.
**b)** Construct the midpoint of each side and line segments joining the adjacent midpoints. Measure the angle at each vertex of the new quadrilateral.

**16. b)** about 1.618:1
**c)** about 1.618:1; predictions may vary
**d)** about 1.618:1
**e)** The ratios are all about 1.618:1.
**f)** Yes. Explanations may vary. For example: The smaller rectangle produced in each step is similar to the rectangles in the preceding steps.
**g)** Answers may vary. For example: Draw the squares such that the position of each new square relative to the square in the previous step follows a clockwise sequence: right, down, left, up, right, down, and so on. Starting from the vertex farthest away from the second square, draw a smooth curve passing through every second vertex of the nested rectangles.

**17. a)** $T\left(\frac{a+c}{2}, \frac{b+d}{2}\right)$, $U\left(\frac{c+e}{2}, \frac{d+f}{2}\right)$, $V\left(\frac{e+g}{2}, \frac{f+h}{2}\right)$, $W\left(\frac{a+g}{2}, \frac{b+h}{2}\right)$
**b)** $m_{TU} = m_{VW} = \frac{f-b}{e-a}$ and $m_{UV} = m_{TW} = \frac{h-d}{g-c}$

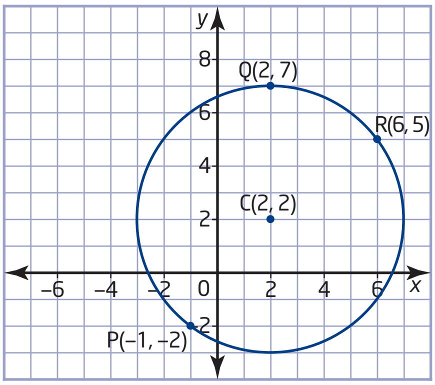
**18.** $\angle BAD + \angle BCD = 180°$

**19.** C

### 3.5 Properties of Circles, pages 145–151

**1. a)** (4, 8) **b)** $-\frac{1}{2}$ **c)** $m_{AB} \times m_{OM} = -1$

**2. a)** CP = CQ = CR = 5
**b)**




**3. a)** $DA = DB = DC = \sqrt{40}$ **b)** $2\sqrt{10}$

**4. a)** $EH = FH = GH = \sqrt{65}$ **b)** $\sqrt{65}$

**5.** O(0, 0) satisfies $y = -4x$, an equation for the right bisector of PQ.

**6. a)** Answers may vary. For example: Substituting into the distance formula shows that the distance from the origin to any point that satisfies $x^2 + y^2 = 45$ is $\sqrt{45}$.
**b)** The coordinates of points R and S satisfy $x^2 + y^2 = 45$.
**c)** $m_{RS} = 3$ and $m_{OM} = -\frac{1}{3}$, so $m_{RS} \times m_{OM} = -1$, where M is the midpoint of RS.

**7.** Answers may vary. For example: Draw any two chords on the circular part. Then, draw the right bisector of each chord. Mark the point of intersection of the right bisectors as the location for the hole.

**8. a)** 0.43 m$^2$ **b)** 0.56 m$^2$ **c)** 0.72 m$^2$
**d)** A circular base gives the maximum area for a given perimeter.

**9.** (−4, 0)

**10.** Answers may vary. For example: Construct line segments AB and BC. Construct the right bisectors of AB and BC. Construct the point of intersection of the right bisectors, and display its coordinates.

**11.** Answers may vary. For example: Fold Sudbury onto Toronto, and fold Windsor onto Toronto. Look for a park near the intersection of the two folds.

**12.** (12, 11)

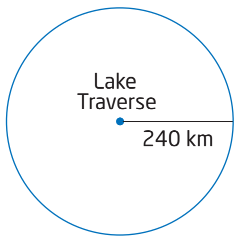
**13.** $\triangle OMP \cong \triangle OMQ$. Explanations may vary. For example: OP and OQ are equal radii, PM = QM, and OM is common to $\triangle OMP$ and $\triangle OMQ$. Therefore, the triangles are congruent (side-side-side).

**14.** Answers may vary. For example: Join point L to point C, the centre of the circle. Since CJ = CL = CK, $\angle CJL = \angle CLJ$ and $\angle CKL = \angle CLK$. The sum of the angles in $\triangle JKL$ is
$$\angle CJL + \angle CLJ + \angle CLK + \angle CKL = 2\angle CLJ + 2\angle CLK = 180°.$$
Since $\angle JLK = \angle CLJ + \angle CLK$, $\angle JLK = 90°$.

**15.** Answers may vary. For example: Construct a circle with diameter JK. Construct any point L on the circle and measure $\angle JLK$. Observe this angle measure while dragging or animating point L around the circumference of the circle.

**16.** Answers may vary. For example:
**a)** Distances from the homes to the hospital are minimized, assuming that the homes are evenly spaced within the circle.
**b)** The homes may be more spread out in some parts of the town. No suitable site may be available at the centre of the circle. Narrow streets or heavy traffic at the centre of the circle could make travel to a central location take longer than to an outlying location.
**c)** Answers will vary.

**17. a)**




**b)** $1.8 \times 10^5$ km$^2$
**c)** Answers may vary. For example: The area between Lake Traverse and the planned destination should be searched first because the plane was probably still headed in that direction when it went missing.

**18.** $\angle ABC = 180° - \frac{1}{2}\angle AOC$

**19.** D

## Chapter 3 Review, pages 152–153

**1.** Answers may vary. For example:

**a)** a line segment that joins a vertex of a triangle to the midpoint of the opposite side

**b)** The medians of a triangle meet at a single point, the centroid. Each median bisects the area of the triangle.

**c)** Construct a triangle and the midpoints of its sides. Construct a line segment from each vertex to the midpoint of the opposite side. Construct and measure the areas of the two triangles formed by each median. Observe the point of intersection of the medians and the area measures while dragging the vertices of the original triangle.

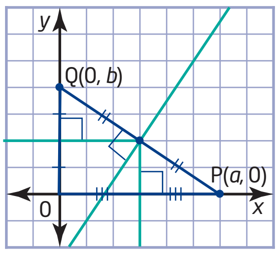
**2.** Answers may vary. For example:

**a)** Since AB = AC, ∠MBC = ∠NCB. MB = NC, and side BC is common to △MBC and △NCB. Therefore, △MBC ≅ △NCB (side-angle-side), and MC = NB.

**b)** Construct an isosceles △ABC with AB = AC. Construct the midpoints of AB and AC. Construct a line segment joining each midpoint to the opposite vertex. Measure the lengths of these line segments and the lengths of AB and AC. Drag the vertices of the triangle to various locations around the screen, making sure that the lengths of AB and AC remain equal. At each new location, compare the lengths of the medians to AB and AC.

**3.** Answers may vary. For example:

**a)**




**b)** For △POQ with vertices P($a$, 0) and Q(0, $b$), the midpoint of OP is $\left(\frac{a}{2}, 0\right)$ and the midpoint of OQ is $\left(0, \frac{b}{2}\right)$. An equation for the right bisector of OP is $x = \frac{a}{2}$, and an equation for the right bisector of OQ is $y = \frac{b}{2}$. These right bisectors intersect at $\left(\frac{a}{2}, \frac{b}{2}\right)$, which is the midpoint of the hypotenuse. Therefore, the point of intersection of the right bisectors of the sides of any right triangle is the midpoint of the hypotenuse.

**c)** Answers may vary. For example: Construct two perpendicular lines, and label the point of intersection A. Construct point B on one of the lines and point C on the other. Construct line segments AB, BC, and AC. Construct the right bisector of each line segment. Observe the point of intersection of the three right bisectors while dragging points B and C along the perpendicular lines.

**4. a)** Since $m_{DE} = \frac{2}{3}$ and $m_{DF} = -\frac{3}{2}$, $m_{DE} \times m_{DF} = -1$ and ∠D is a right angle.

**b)** Calculate the lengths of the sides and show that they satisfy the Pythagorean theorem.

**5.** Answers may vary. For example:

**a)** The midpoint of KL is M(0, 3). Since $m_{KL} = 5$ and $m_{JM} = -\frac{1}{5}$, $m_{KL} \times m_{JM} = -1$ and JM is perpendicular to KL.

**b)** Since JK = JL, △JKL is isosceles.

**6.** Answers may vary. For example:

**a)** The diagonals of a square bisect each other and are perpendicular.

**b)** The diagonals of a parallelogram bisect each other and bisect the area of the parallelogram.

**c)** The diagonals of a kite are perpendicular, and the diagonal joining the vertices between the equal sides bisects the other diagonal.

**7.** Answers may vary. For example:

**a)** Since EF is parallel to AD and BC, AEFD and EBCF are parallelograms. AEFD and EBCF have the same base length as ABCD, but half the height. Therefore, AEFD and EBCF each have half the area of ABCD.

**b)** Use geometry software to construct a parallelogram ABCD with the vertices at the points of intersection of two pairs of parallel lines. Construct the midpoints, E and F, of one pair of opposite sides. Construct a line segment EF. Measure the areas of AEFD and EBCF. Compare these areas while dragging the vertices of ABCD.

**8.** Since $m_{JM} = m_{KL} = \frac{1}{3}$, JM is parallel to KL.

**9. a)** Rectangle. Explanations may vary. For example: Calculating the slopes shows the adjacent sides are all perpendicular to each other. Calculating the lengths of the sides shows that opposite sides have equal lengths, but adjacent sides do not.

**b)** $M\left(4\frac{1}{2}, 1\frac{1}{2}\right)$ is the midpoint of both TV and UW. Therefore, the diagonals of TUVW bisect each other.

**10.** Answers may vary. For example:

**a)** A(−12, −5) and B(12, 5) both satisfy the equation for the circle, and AB = 26, exactly twice the radius of the circle.

**b)** (12, −5) or (13, 0).

**c)** $m_{AC} \times m_{BC} = -1$, so ∠C is a right angle.

**11. a)** The coordinates of points P and Q satisfy the equation for the circle.

**b)** O(0, 0) satisfies $y = \frac{1}{6}x$, an equation of the right bisector of PQ.

**12.** Answers may vary. For example: On a map, draw the line segments joining St. Catharines to Hamilton and Hamilton to Oakville. Construct the right bisector of each line segment. The point of intersection of the right bisectors represents the centre of the circle that passes through St. Catharines, Hamilton, and Oakville.

### Chapter 3 Practice Test, page 154–155

**1.** A, B, and E
**2.** A, B, and E
**3.** Diagrams may vary.
**4.** Let $\triangle ABC$ be an isosceles triangle with AB = AC and altitudes BP and CQ. $\angle QAP$ is common to $\triangle ABP$ and $\triangle ACQ$, AB = AC, and $\angle APB = \angle AQC = 90°$. Therefore, $\triangle ABP \cong \triangle ACQ$ (angle-angle-side), and PB = QC.
**5.** **a)** $AB = BC = \sqrt{80}$
**b)** (6, −1) satisfies equations for all three medians ($y = -x + 5$, $x = 6$, and $y = -1$).
**6.** **a)** Since $m_{DE} = 2$ and $m_{DF} = -\frac{1}{2}$, $m_{DE} \times m_{DF} = -1$ and $\angle D = 90°$.
**b)** $GD = GE = GF = \sqrt{10}$, where G is the midpoint of EF.
**7.** **a)** $JK = KL = LM = JM = \sqrt{29}$
**b)** Answers may vary. For example: Construct quadrilateral JKLM. Then, measure and compare the lengths of JK, KL, LM, and JM.
**8.** **a)** A(−1, 9), B(3, 8), C(6, 1), and D(2, 2)
**b)** $m_{AB} = m_{CD}$ and $m_{AD} = m_{BC}$
**9.** **a)** CT = CU = CV = 13
**b)** 13
**10.** AD = BC but $m_{AB} \neq m_{CD}$
**11.** Answers may vary. For example: Construct quadrilateral ABCD. Measure and compare the lengths and slopes of the four sides.
**12.** **a)** PQ = QR = RS = PS = 5
**b)** The midpoints of diagonals PR and SQ are both (6, 0).
**c)** Since $m_{PR} = -\frac{1}{2}$ and $m_{SQ} = 2$, $m_{PR} \times m_{SQ} = -1$ and the diagonals are perpendicular.
**13.** Answers may vary. For example: The point (25, 37) would be a good location because it is equidistant from all four towns.

### Chapters 1 to 3 Review, pages 156-157

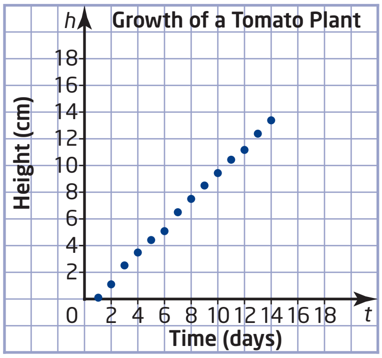
**1.** **a)** $x = \frac{5}{7}$, $y = 1\frac{1}{7}$ **b)** $x = 1$, $y = 2$
**c)** $x = 6$, $y = 5$ **d)** $x = \frac{4}{5}$, $y = 3\frac{3}{5}$
**2.** 65 adults; 55 students
**3.** 19 kW; 38 kW
**4.** sander \$6/h, polisher \$4/h
**5.** **a)** 75 T-shirts **b)** \$750
**6.** 30 kg of mocha coffee beans, 20 kg of java coffee beans
**7.** **a)** midpoint of AB is (0, 2); midpoint of AC is (3, 1); midpoint of BC is (1, −1)
**b)** $4\sqrt{10} + 4\sqrt{2}$, or approximately 18.3 units
**8.** **b)** $x = \frac{7}{2}$ **c)** $y = \frac{1}{2}x + \frac{15}{4}$ **d)** $\left(\frac{7}{2}, \frac{11}{2}\right)$
**e)** $ME = MD = MF = \frac{5\sqrt{2}}{2}$, therefore M is equidistant from vertices D, E, and F.
**9.** right isosceles; Reasons may vary. Using the Pythagorean theorem, $GH = HI = \sqrt{40}$ and $GI = \sqrt{80}$. So $GI^2 = GH^2 + HI^2$.
**10.** midpoint coordinates are M(2, 1) and N(5, 2); compare slopes: $m_{JL} = \frac{1}{3}$, $m_{MN} = \frac{1}{3}$. Since $m_{JL} = m_{MN,}$ MN is parallel to JL.
**11.** **a)** $x^2 + y^2 = 49$ **b)** $x^2 + y^2 = 10$ **c)** $x^2 + y^2 = 169$
**12.** 25.1 m
**13.** **b)** $m_{PQ} = \frac{3}{2}$, $m_{QR} = -\frac{2}{3}$. Since $m_{PQ} \times m_{QR} = -1$, PQ is perpendicular to QR. Therefore $\triangle PQR$ is a right triangle.
**c)** $PQ = 2\sqrt{13}$; $QR = 2\sqrt{13}$; $PR = 2\sqrt{26}$; Since PQ = QR, the triangle is also isosceles.
**d)** 26 square units
**14.** Methods will vary.
**15.** **b)** an isosceles triangle
**c)** $AB = 4\sqrt{2}$; $BC = 2\sqrt{10}$; $AC = 2\sqrt{10}$. Since AC = BC, $\triangle ABC$ is isosceles.
**d)** The midpoint of AB is D(1, 3). $m_{AB} = 1$, $m_{CD} = -1$; since $m_{AB} \times m_{CD} = -1$, the median CD is perpendicular to AB, and it must also be an altitude of the triangle.
**16.** $m_{DE} = -\frac{1}{3}$, $m_{GF} = -\frac{1}{3}$, so DE is parallel to GF. $m_{EF} = -3$, $m_{DG} = -3$, so EF is parallel to DG. Compare side lengths: $DE = \sqrt{10}$, $GF = \sqrt{10}$, $EF = \sqrt{10}$, $DG = \sqrt{10}$; So, DE = GF and EF = DG. Since opposite sides are parallel and equal in length, DEFG is a rhombus.
**17.** $m_{PQ} = -1$, $m_{RS} = -1$, so PQ is parallel to RS. $m_{QR} = \frac{2}{3}$, $m_{SP} = \frac{2}{3}$; so QR is parallel to SP. Compare side lengths: $PQ = 2\sqrt{2}$, $QR = \sqrt{13}$, $RS = 2\sqrt{2}$, $SP = \sqrt{13}$. Since opposite sides are parallel and equal in length, PQRS is a parallelogram.
**18.** **a)** The midpoint of TW is M(1, 0); $TW = 4\sqrt{5}$; $TM = 2\sqrt{5}$; Since the length of TM is one half the length of TW, the point M bisects the diagonal TW. The midpoint of UV is also M(1, 0); $UV = 2\sqrt{5}$; $UM = \sqrt{5}$; Since the length of UM is one half the length of UV, the point M bisects the diagonal UV. Compare slopes: $m_{TW} = -\frac{1}{2}$, $m_{UV} = 2$. Since $m_{TW} \times m_{UV} = -1$, TW is perpendicular to UV. Therefore the diagonals quadrilateral TUVW are right bisectors of each other.
**b)** Methods will vary.

## Chapter 4

### Get Ready, pages 162–163

**1. a)** independent variable: time; dependent variable: height

**b)**

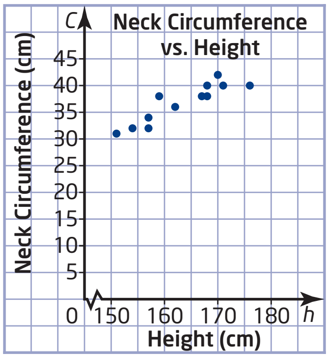



**c)** Linear; the points lie on a straight line.

**d)** 16.4 cm

**2. a)** independent variable: height; dependent variable: neck circumference

**b)**

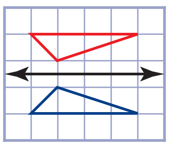



**c)** Linear; the points lie on a straight line.

**d)** 44 cm

**3.** The red figure is shifted 4 units left and 1 unit up.

**4.**



**5. a)** $2^7$ **b)** $(-1)^7$ **c)** $\left(\frac{1}{2}\right)^5$

**d)** $5^5$ **e)** $(-3)^3$ **f)** $4^{10}$

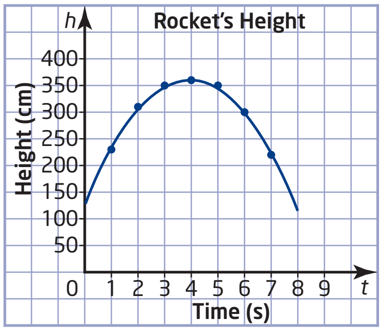
**6. a)** $2^2$ **b)** $(-3)^6$ **c)** $5^5$ **d)** $4^2$

### 4.1 Investigate Non-Linear Relations, pages 164–167

**1.** The scatter plot in part b) could be modelled using a curve because the points do not lie along a line.

**2.** Non-linear; the points lie on a curve.

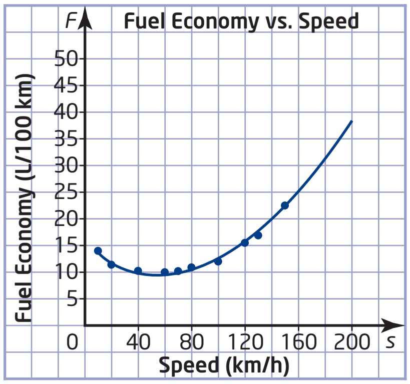
**3. a), c)**




**b)** Non-linear; the points lie on a curve.

**d)** Answers will vary. For example: 111 m

**4. a), c)**

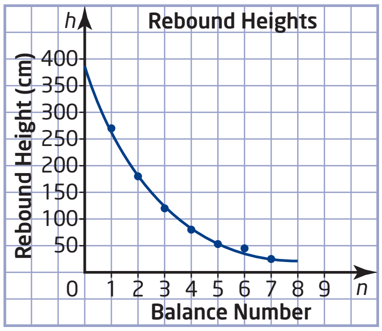



**b)** Non-linear; the points lie on a curve.

**d)** Answers will vary. For example: 40 L/100 km

**e)** The graph for a car with better fuel economy would be translated down compared to the graph in part a).

**5. a), c)**



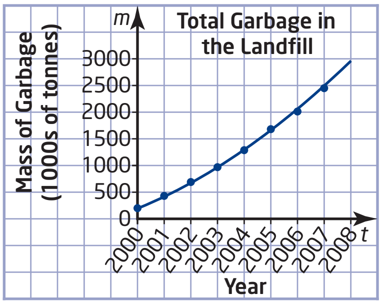

**b)** Non-linear; the points lie on a curve.

**d)** If the ball were bouncier, the rebound heights would not decrease as fast as in this graph.

**6. a)**

| Year | Total Garbage (1000s of tonnes) |
|---|---|
| 2000 | 200 |
| 2001 | 430 |
| 2002 | 688 |
| 2003 | 975 |
| 2004 | 1292 |
| 2005 | 1639 |
| 2006 | 2015 |
| 2007 | 2421 |

**b)**

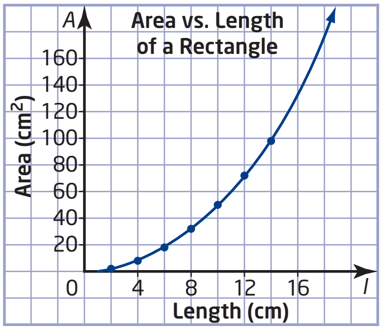



**c)** Answers will vary. For example: The city will run out of landfill space.

**7. a)**

| Length (cm) | Area (cm$^2$) |
|---|---|
| 2 | 2 |
| 4 | 8 |
| 6 | 18 |
| 8 | 32 |
| 10 | 50 |
| 12 | 72 |
| 14 | 98 |
| 16 | 128 |

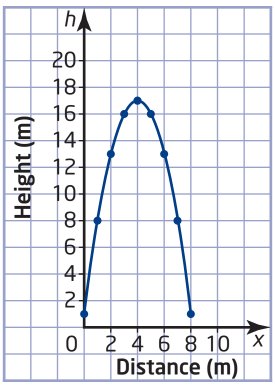
**b), c)**




**d)** Answers will vary. For example: This relation is non-linear because length is a linear measurement but area is a square measurement.

## 4.2 Quadratic Relations, pages 168–173

**1. a)**

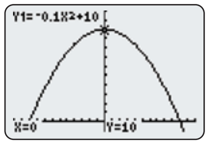



**b)** The flight path of the ball is parabolic. The axis of symmetry is $x = 4$ and the vertex is (4, 17).

**c)** The maximum height reached is 17 m.

**d)** A table of values for $h = -x^2 + 8x + 1$ is the same as the table of values given.

**2. a)**




**b)** The shape of the arch is parabolic.

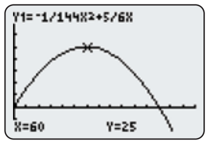
**c)** The arch is 10 m tall and 20 m wide.

**3. a)** linear **b)** quadratic

**c)** neither **d)** quadratic

**4.** Answers will vary.

**5. a)**

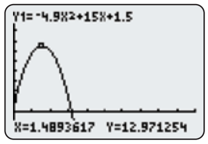



**b)** 9 m **c)** 120 m

**d)** The maximum height is 25 m at a horizontal distance of 60 m.

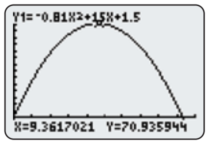
**e)** $x = 60$

**6. a)**



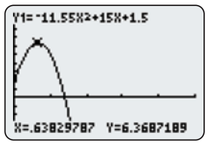

**b)** There is a quadratic relation between time and height.

**c)**




There is a quadratic relation.

**d)**




There is a quadratic relation.

**e)** All three show a quadratic relation between time and height, but the parabolas have different axes of symmetry and vertices. Since the ball falls to the ground faster on Jupiter than on Earth and the Moon, Jupiter has a stronger force of gravity than Earth and the Moon.

**7.** The relation is more closely modelled by a quadratic equation because the second differences are very close to being constant.

**8.** Tables may vary. The arch does not closely resemble a parabola. The second differences are not constant.

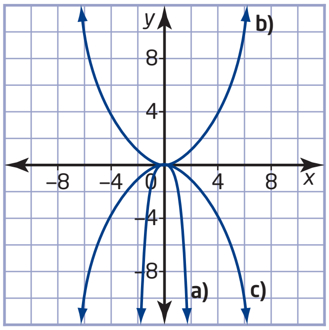
| $x$ | $y$ | First Differences | Second Differences |
|---|---|---|---|
| –1.5 | 1.0 | | |
| –1.0 | 1.5 | 0.5 | –0.25 |
| –0.5 | 1.75 | 0.25 | 0.25 |
| 0.0 | 2.25 | 0.50 | –0.35 |
| 0.5 | 2.4 | 0.15 | –0.30 |
| 1.0 | 2.25 | –0.15 | 0.10 |
| 1.5 | 2.2 | –0.05 | –0.15 |
| 2.0 | 2.0 | –0.20 | –0.05 |
| 2.5 | 1.75 | –0.25 | –1.00 |
| 3.0 | 0.75 | –1.25 | |

**10.** 18 min 31 s

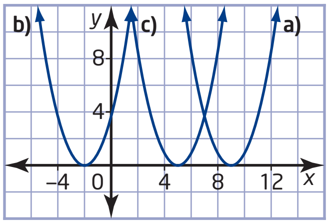
**11.** $y = \frac{n(n + 1)}{2}$. For $n = 6$, $y = \frac{6(7)}{2} = 21$ and $1 + 2 + 3 + 4 + 5 + 6 = 21$.

## 4.3 Investigate Transformations of Quadratics, pages 174–179

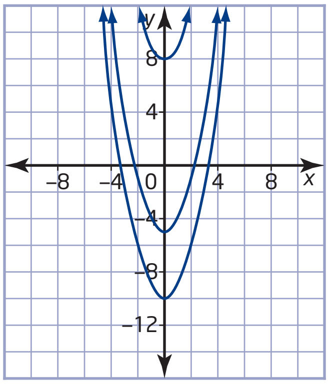
**1.**



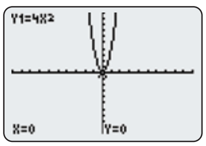

**2.**




**3.**

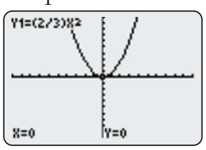



**4. a)**



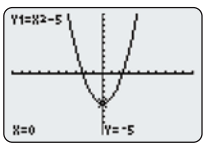

The parabola is vertically stretched by a factor of 4.

**b)**



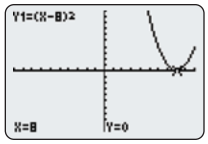

The parabola is vertically compressed by a factor of $\frac{2}{3}$.

**c)**



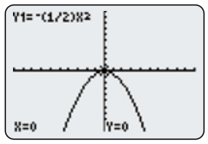

The parabola is translated 5 units downward.

**d)**



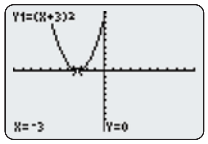

The parabola is translated 8 units to the right.

**e)**



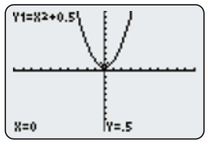

The parabola is compressed vertically by a factor of $\frac{1}{2}$ and reflected in the $x$-axis.

**f)**



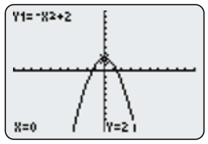

The parabola is translated 3 units to the left.

**g)**




The parabola is translated 0.5 units upward.

**h)**




The parabola is reflected in the $x$-axis and translated 2 units upward.

**5. a)**

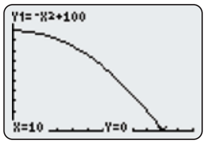
| $x$ | $y = x^2$ | $y = 2x^2$ | $y = x^2 + 1$ | $y = (x - 3)^2$ |
|---|---|---|---|---|
| –3 | 9 | 18 | 10 | 36 |
| –2 | 4 | 8 | 5 | 25 |
| –1 | 1 | 2 | 2 | 16 |
| 0 | 0 | 0 | 1 | 9 |
| 1 | 1 | 2 | 2 | 4 |
| 2 | 4 | 8 | 5 | 1 |
| 3 | 9 | 18 | 10 | 0 |

**b)** The $y$-values for $y = 2x^2$ are all twice the $y$-values for $y = x^2$.
**c)** The $y$-values for $y = x^2 + 1$ are all 1 more than the $y$-values for $y = x^2$.
**d)** The $y$-values for $y = (x - 3)^2$ are the same as the $y$-values for $y = x^2$ for $x$-values that are 3 greater.

**6. a)** $y = x^2 + 6$ **b)** $y = x^2 - 4$

**7. a)** $y = (x + 7)^2$ **b)** $y = (x - 5)^2$
**c)** $y = (x + 8)^2$ **d)** $y = (x - 3)^2$

**8. a)** $y = 8x^2$ **b)** $y = \frac{1}{5}x^2$

**9. a)** 


**b)** The $A$-intercept is 100. This represents the area of grass if there is no square patio in the centre of the grass. The $x$-intercept is 10. This represents the side length of the patio, in metres, if the patio completely covers the grass in the backyard.

**c)** $A = -x^2 + 144$

**d)** $x$ must be greater than or equal to zero but less than or equal to 10 m and 12 m, respectively.

**10. a)** 100 m; 400 m

**b)** When the speed of the car doubles, the length of the skid mark quadruples.

**c)** $s$ must be greater than 0.

**d)** Answers may vary. For example: If the pavement were wet, the skid marks would be longer. The equation would have a coefficient greater than 0.04.

**11. a)**

| *l* | *A* | First Differences | Second Differences |
|---|---|---|---|
| 2 | 3 | | |
| | | 5 | |
| 3 | 8 | | 2 |
| | | 7 | |
| 4 | 15 | | 2 |
| | | 9 | |
| 5 | 24 | | 2 |
| | | 11 | |
| 6 | 35 | | |

The equation is quadratic. The second differences are constant.

**b)** $A = l^2 - 1$

**c)** The transformation is a translation of 1 unit downward.

**12. a)** Answers will vary. For example: According to the order of operations, multiplying by $a$ or adding $k$ is done after squaring the $x$-value, so the transformation applies directly to the parabola $y = x^2$. Because the value of $h$ must be added or subtracted before squaring, the shift is opposite to the sign in the bracket and must be the opposite movement to get back to the original $y$-value for the graph of $y = x^2$.

**b)** The graph of $y = (2x)^2$ is the graph of $y = x^2$ stretched vertically by a factor of 4.

**13.** $a = -2$, $k = 5$

**14.** The graphs of $y = (x - 2)^2$ and $y = (2 - x)^2$ are exactly the same.

**15. a)** Answers will vary. For example: The graphs are both parabolas; $y = (x - 2)^2 + 5$ opens upward and $x = (y - 2)^2 + 5$ opens to the right. The vertices are (2, 5) and (5, 2), respectively. The equations of the axes of symmetry are $x = 2$ and $y = 2$, respectively. The $x$ and $y$ variables have switched in the equations.

**b)** $y = 2 \pm 2\,\overline{x - 5}$

### 4.4 Graph $y = a(x - h)^2 + k$, pages 180–188

**1. a)**

| Property | $y = (x - 4)^2$ |
|---|---|
| Vertex | (4, 0) |
| Axis of symmetry | $x = 4$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geqslant 0$ |

**b)**

| Property | $y = (x - 2)^2 - 4$ |
|---|---|
| Vertex | (2, −4) |
| Axis of symmetry | $x = 2$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geqslant -4$ |

**c)**

| Property | $y = (x + 3)^2 - 2$ |
|---|---|
| Vertex | (−3, −2) |
| Axis of symmetry | $x = -3$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geqslant -2$ |

**d)**

| Property | $y = \frac{1}{2}(x + 1)^2 + 5$ |
|---|---|
| Vertex | (−1, 5) |
| Axis of symmetry | $x = -1$ |
| Stretch or compression factor relative to $y = x^2$ | $\frac{1}{2}$ |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geqslant 5$ |

**e)**

| Property | $y = (x - 7)^2 - 3$ |
|---|---|
| Vertex | (7, −3) |
| Axis of symmetry | $x = 7$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geqslant -3$ |

**f)**

| Property | $y = -(x - 1)^2 + 7$ |
|---|---|
| Vertex | (1, 7) |
| Axis of symmetry | $x = 1$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | downward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \leqslant 7$ |

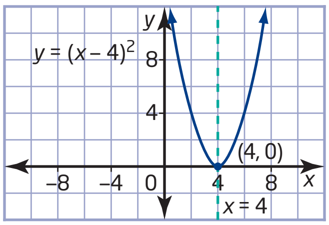
**g)**

| Property | $y = 2(x - 4)^2 - 5$ |
|---|---|
| Vertex | (4, −5) |
| Axis of symmetry | $x = 4$ |
| Stretch or compression factor relative to $y = x^2$ | 2 |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geqslant -5$ |

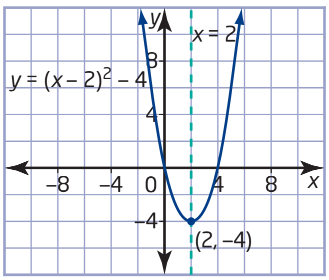
**h)**

| Property | $y = -3(x + 4)^2 - 2$ |
|---|---|
| Vertex | (−4, −2) |
| Axis of symmetry | $x = -4$ |
| Stretch or compression factor relative to $y = x^2$ | 3 |
| Direction of opening | downward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \leqslant -2$ |

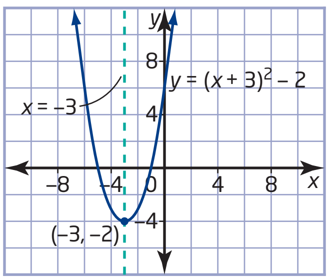
**2. a)**



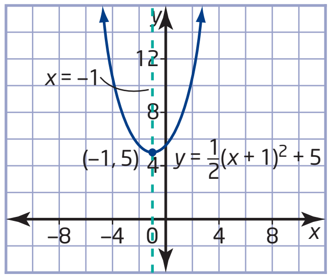

**b)**



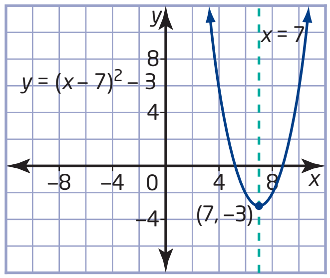

**c)**



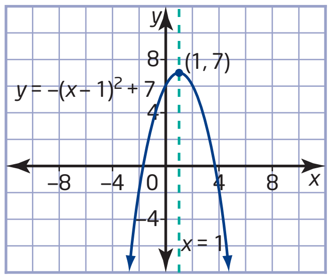

**d)**



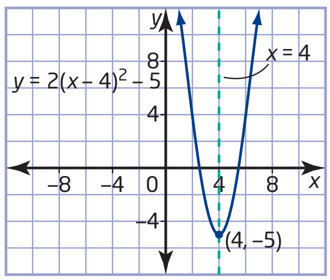

**e)**



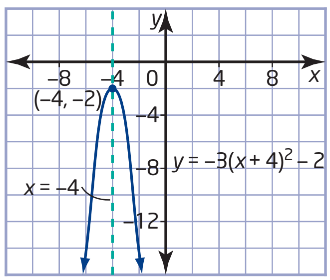

**f)**




**g)**




**h)**



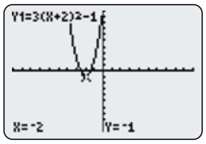

**3.** $y = (x - 2)^2 + 3$

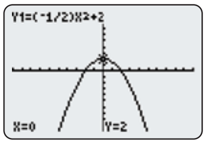
**4.** $y = -2(x + 3)^2$

**5.** $y = 0.3(x - 4)^2 - 1$

**6. a)** $y = (x - 4)^2$ **b)** $y = -(x + 3)^2$

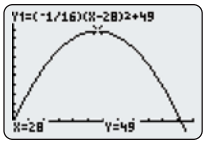
**7. a)** $y = (x - 4)^2 - 5$ **b)** $y = -(x + 6)^2 + 4$
**c)** $y = 5(x - 6)^2 - 7$

**8.** 


**9.** 


**10. a)** $y = (x - 1)^2 + 4$ **b)** $y = -(x + 2)^2 + 5$

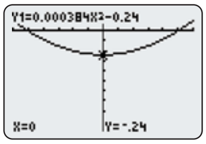
**11.** B is correct. The parabola opens downward and has a $y$-intercept of 20.

**12. a)** 


**b)** 49 m **c)** 28 m **d)** 45 m **e)** 36 m

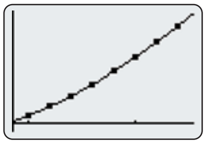
**13. a)** $h = -2(d - 4)^2 + 33$ **b)** 25 m **c)** 2 m

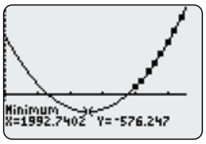
**14. a)** 127 m; 5 s **b)** 2 m

**15. a)** 


**b)** $y = 0.000\,384x^2 - 0.24$; $-25 \leqslant x \leqslant 25$

**c)** Answers will vary.

**16. a)** 

**b)** 


**c)** $y = 14.6(x - 1992.7)^2 - 576.2$

**d)** Realistically, $x \geqslant 2000$ and $y \geqslant 200$.

**17.** left parabola: $y = 0.012(x + 100)^2$ for $-100 \leqslant x \leqslant -50$; middle parabola: $y = 0.012x^2$ for $-50 \leqslant x \leqslant 50$; right parabola: $y = 0.012(x - 100)^2$ for $50 \leqslant x \leqslant 100$

**19. a)** $y = -2(x - 4)^2 + 1$ **b)** $y = 2x^2 - 1$

**c)** $y = -2(x - 4)^2 + 4$ **d)** $y = 2(x + 4)^2 - 1$

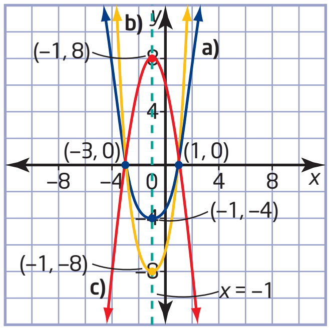
**20. a)** $x^2 + (y - 3)^2 = 25$; $(x - 6)^2 + (y - 1)^2 = 49$; $(x + 3)^2 + (y - 5)^2 = 64$; $(x - h)^2 + (y - k)^2 = r^2$

**b)** Answers will vary. For example: A circle with equation $(x - h)^2 + (y - k)^2 = r^2$ has centre $(h, k)$ and a parabola with equation $y = (x - h)^2 + k$ has vertex $(h, k)$.

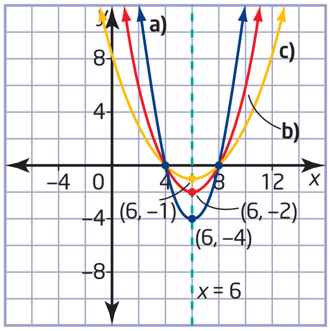
**21.** $y = \frac{1}{14}x^2 - \frac{3}{7}x - \frac{6}{7}$

**22.** C

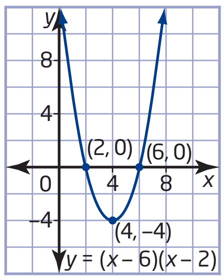
### 4.5 Quadratic Relations of the Form $y = a(x - r)(x - s)$, pages 189–193

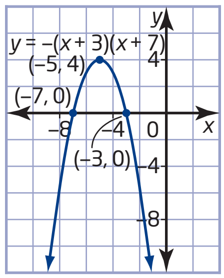
**1.** 

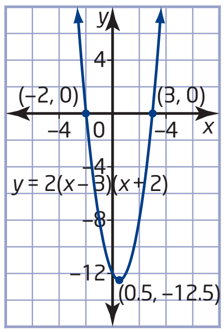

The graphs all have the same $x$-intercepts and axis of symmetry, but differ in the vertical stretch of the parabola and direction of opening.

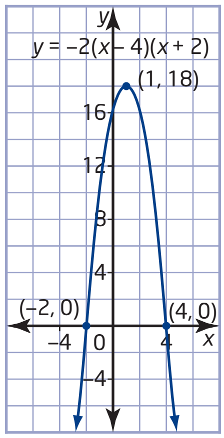
**2.** 


The graphs all have the same $x$-intercepts, axis of symmetry, and direction of opening, but differ in the vertical stretch of the parabola.

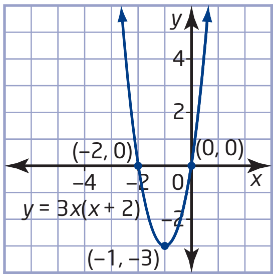
**3. a)** 


**b)** 

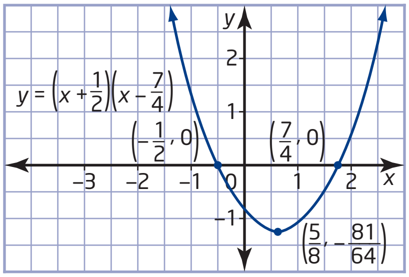

**c)** 


**d)** 

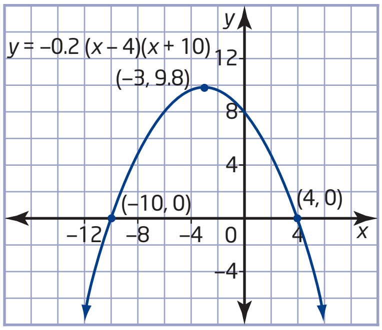
**4. a)**



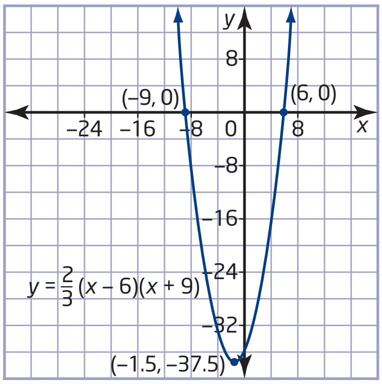

**b)**



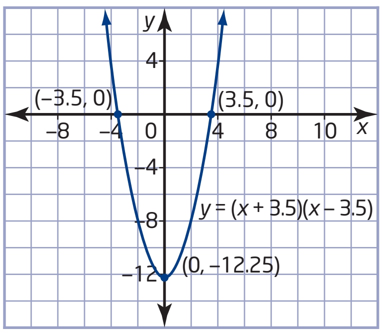

**c)**



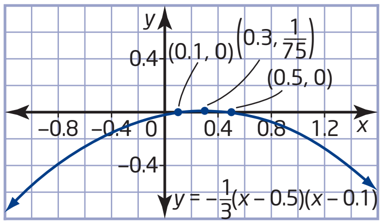

**d)**




**e)**




**f)**

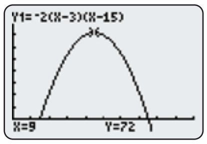



**5. a)** $y = 0.5(x + 7)(x + 3)$ **b)** $y = -4(x - 2)(x - 4)$

**6. a)** (5, 0) **b)** 1 **c)** $y = (x - 5)(x - 5)$

**7. a)** −2 and −2 **b)** (−2, 0)

**8. a)**

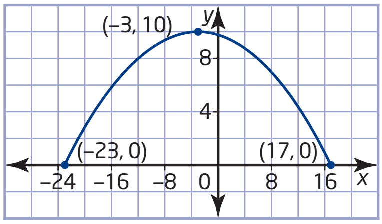



**b)** 15 m

**c)** 72 m when it is 9 m from the wall

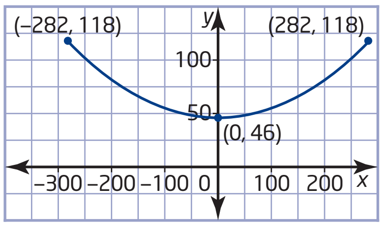
**9.** When the $x$-intercepts are opposite values, the vertex has an $x$-coordinate of 0.
Answers may vary. For example: $y = 3(x - 2)(x + 2)$

**10. a)**



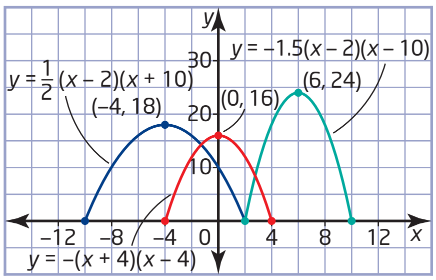

**b)** $y = -\frac{1}{40}(x + 23)(x - 17)$

**11. a)**




**b)** It is not possible to write an equation in the form $y = a(x - r)(x - s)$ because the graph has no $x$-intercepts.

**12. a)**

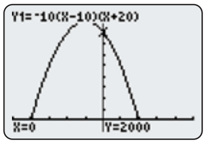



**b)** 20 m

**c)** 18 m, 16 m, 24 m

13. **a)** $R = -10(x - 10)(x + 20)$

**b)**

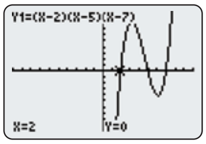



**c)** The $R$-intercept represents the current revenue with the current price of a ticket at \$20 each. The $x$-intercepts represent the number of price increases or decreases that would give a revenue of \$0.

**d)** A negative $x$-value represents a decrease in the ticket price.

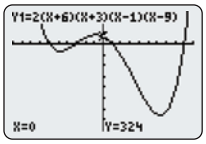
**e)** \$15 per ticket

14. **a)**



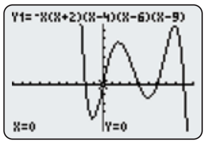

The equation of the relation has three factors. The graph of the relation crosses the $x$-axis at three points. The three points are the $x$-intercepts of the relation.

**b)**




The equation of the relation has four factors. The graph of the relation crosses the $x$-axis at four points. The four points are the $x$-intercepts of the relation.

**c)**




The equation of the relation has five factors. The graph of the relation crosses the $x$-axis at five points. The five points are the $x$-intercepts of the relation.

15. $\sqrt{137}$ units

## 4.6 Negative and Zero Exponents, pages 194–201

1. **a)** $\frac{1}{3^2}$ **b)** $\frac{1}{5^1}$ **c)** $\frac{1}{10^4}$

**d)** $\frac{1}{7^3}$ **e)** $\frac{1}{(-2)^4}$ **f)** $\frac{1}{(-7)^1}$

2. **a)** $\frac{1}{36}$ **b)** 1 **c)** $\frac{1}{7}$ **d)** $\frac{1}{1000}$

**e)** $-\frac{1}{9}$ **f)** $\frac{1}{144}$ **g)** 1 **h)** $-1$

3. **a)** 9 **b)** undefined **c)** $-4$

**d)** $\frac{36}{25}$ **e)** $\frac{4096}{81}$ **f)** $\frac{64}{729}$

4. **a)** $1\frac{1}{36}$ **b)** $7\frac{7}{8}$ **c)** 1 **d)** 2

5. **a)** $\frac{1}{16}$ **b)** $\frac{1}{64}$ **c)** $2^{-4}$, $2^{-6}$

6. **a)** 0.125 kg **b)** 0.015 625 kg

7. **a)** $2^{-4}$ **b)** 0.5 mg

8. **a)** 3 **b)** $\frac{5}{4}$ **c)** $-2$ **d)** $-3$

9. Answers will vary.

10. Answers will vary.

11. **a)** 4000, 8000, 16 000, 32 000

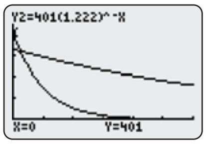
**b)** $t = 0$ represents June 1.

**c)** $t = -1$ could mean 1 month ago, or May 1.

**d)** There were 125 bees 3 months ago on approximately March 1. Let $t = -3$ represent 3 months ago and solve for the number of bees.

12. **a)** A negative exponent is used because the intensity of light energy is decreasing.

**b)**

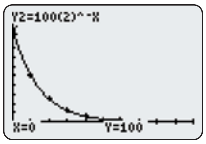



**c)** The light intensity decreases more quickly in Lake Erie because the base is greater.

14. **a)** 99.902 343 75 m

**b)** No, because he will always be walking a distance of half the previous distance. Looking at the graph, the curve will never reach zero, which is the remaining distance needed in order for Chris to reach the end of the track.

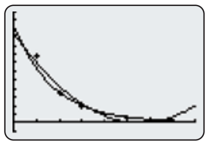
| Time (min) | Distance Remaining (m) |
|---|---|
| 1 | 50 |
| 2 | 25 |
| 3 | 12.5 |
| 4 | 6.25 |
| 5 | 3.125 |
| 6 | 1.562 5 |
| 7 | 0.781 25 |
| 8 | 0.390 625 |
| 9 | 0.195 312 5 |
| 10 | 0.097 656 25 |




**c)** $d = 100(2)^{-t}$

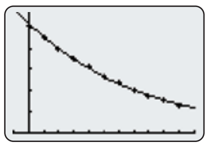
15. **a)** $m = 500(0.9)^{-t}$ **b)** 44 h

16. **a)–c)**

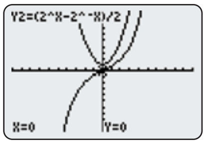


**d)** The exponential model fits the data better.

17. **a), b)**



**c)** An exponential model is better because the atmospheric pressure will never reach 0 millibars.

**18.** 

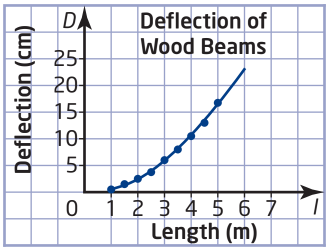

The graph of $y = x^2 + 1$ is a parabola with vertex (0, 1), opening up. When $x < 0$, the graph of $y = \dfrac{2^x - 2^{-x}}{2}$ looks like a parabola that opens downward, but is wider than the parabola $y = x^2 + 1$. When $x > 0$, the graph of $y = \dfrac{2^x - 2^{-x}}{2}$ looks like a parabola that opens upward and is wider than the parabola for $y = x^2 + 1$. The graph of $y = \dfrac{2^x - 2^{-x}}{2}$ crosses the $y$-axis at the origin and changes direction at this point.

**19. a)** $x = -4$ **b)** $x = -2$

**20. a)** 13 **b)** $-30$

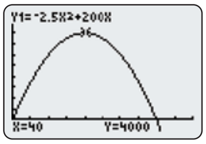
## Chapter 4 Review, pages 202–203

**1.** The graph in part b) can be modelled using a curve because the points lie on a curve.

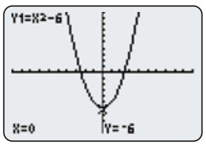
**2. a)** 


**b)** There is a non-linear relation between the variables.
**c)** 23.5 cm

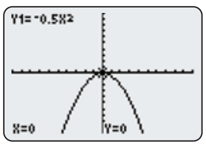
**3. a)** quadratic **b)** neither **c)** linear

**4. a)** 

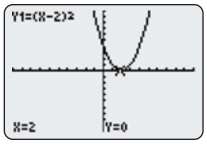

**b)** 80 min
**c)** The maximum height of 4000 m is reached after 40 min.

**5. a)** 

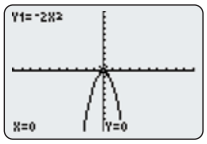

The graph of $y = x^2 - 6$ is the graph of $y = x^2$ translated 6 units downward.

**b)** 


The graph of $y = -0.5x^2$ is the graph of $y = x^2$ reflected in the $x$-axis and compressed vertically by a factor of 0.5.

**c)** 


The graph of $y = (x - 2)^2$ is the graph of $y = x^2$ translated 2 units to the right.

**d)** 


The graph of $y = -2x^2$ is the graph of $y = x^2$ reflected in the $x$-axis and stretched vertically by a factor of 2.

**6. a)**

| Property | $y = (x - 1)^2 - 4$ |
|---|---|
| Vertex | (1, −4) |
| Axis of symmetry | $x = 1$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geq -4$ |

**b)**

| Property | $y = 2(x + 3)^2 + 1$ |
|---|---|
| Vertex | (−3, 1) |
| Axis of symmetry | $x = -3$ |
| Stretch or compression factor relative to $y = x^2$ | 2 |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geq 1$ |

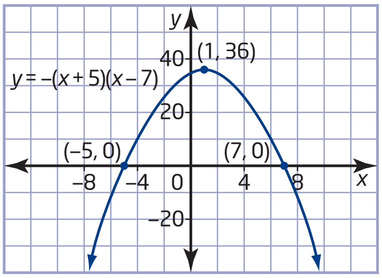
**c)**

| Property | $y = \frac{1}{4}(x - 5)^2 + 1$ |
|---|---|
| Vertex | (5, 1) |
| Axis of symmetry | $x = 5$ |
| Stretch or compression factor relative to $y = x^2$ | $\frac{1}{4}$ |
| Direction of opening | upward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \geq 1$ |

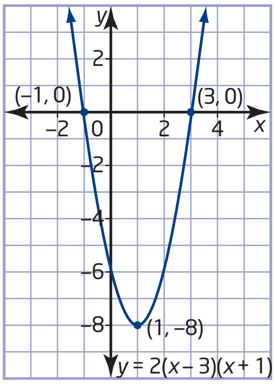
**d)**

| Property | $y = -(x + 2)^2 + 6$ |
|---|---|
| Vertex | (−2, 6) |
| Axis of symmetry | $x = -2$ |
| Stretch or compression factor relative to $y = x^2$ | none |
| Direction of opening | downward |
| Values $x$ may take | set of real numbers |
| Values $y$ may take | $y \leq 6$ |

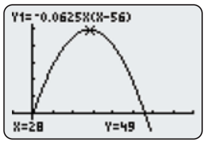
**7. a)**




**b)**




**8. a)**




**b)** 56 m

**c)** 28 m; 49 m

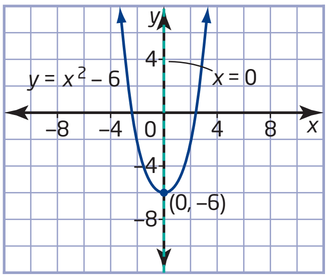
**9. a)** $\frac{1}{49}$ **b)** 1 **c)** $\frac{1}{100\ 000}$ **d)** 1

**e)** $-\frac{1}{6}$ **f)** $\frac{1}{49}$ **g)** 1 **h)** $-\frac{125}{8}$

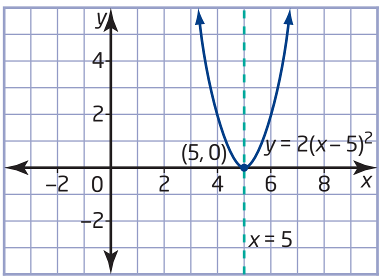
**10. a)** $\frac{1}{64}$ **b)** $\frac{1}{4096}$ **c)** $2^{-6}$, $2^{-12}$ **d)** \$244.14

### Chapter 4 Practice Test, pages 204–205

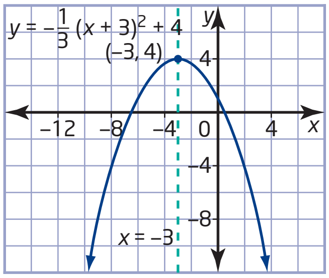
**1. a)**



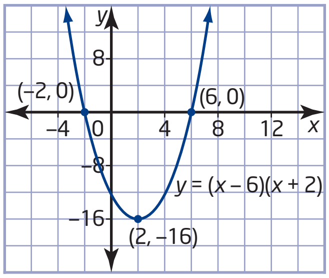

**b)**



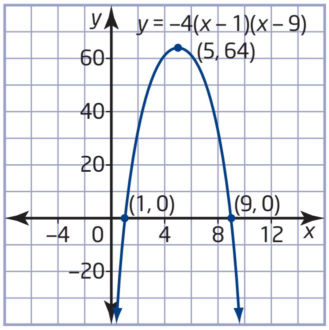

**c)**




**2. a)**




**b)**

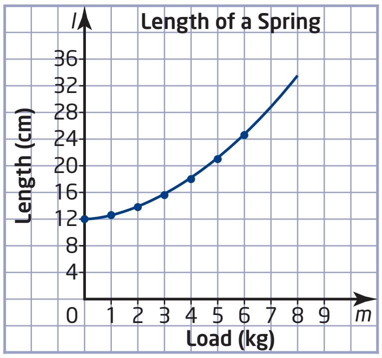



**3. a)** $y = (x - 5)^2 + 2$ **b)** $y = -\frac{1}{6}(x - 2)^2 + 6$

**4. a)** 1 **b)** $\frac{1}{5}$ **c)** $-\frac{1}{27}$ **d)** $\frac{16}{9}$

**5. a)** quadratic

**b)**

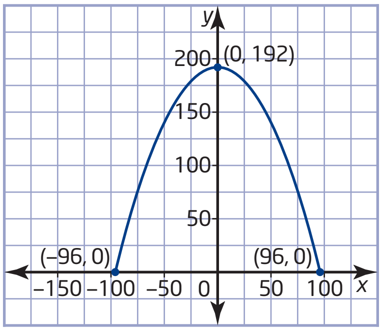



**c)** 33.6 cm

**6. a)** 371 **b)** 2418.5

**c), d)** Answers will vary.

**7. a), b)**



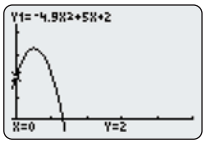

**c)** $y = -\frac{1}{48}x^2 + 192$

**8.** Answers will vary. For example: If a car uses tires with better grip, then the minimum turn radius will decrease. The value of $a$ will be less than 0.6.

**9. a)** 46.875 m

**b)** If you were standing on a 20-m cliff, you would use the formula $h = \frac{3}{40}d^2 - 20$, where $h$ represents the height above the cliff.

**10. a)**




**b)** The $h$-intercept is 2 and it represents the height, in metres, of the volleyball when it was first hit.

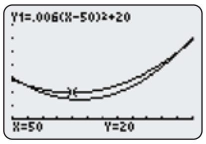
**c)** 1.3 s; the $x$-intercept tells you when the volleyball will hit the ground ($h = 0$).

**11. a)** 20 000, 40 000, 80 000, 160 000

**b)** $t = 0$ represents present time, or July 1; $t = -2$ represents 2 years ago.

**c)** 3 years ago, because $5000(2)^{-3} = 625$

**12.**




For speeds from 0 km/h to 17.1 km/h, the cost of operating the first car is less than that of the second car. For speeds from 17.1 km/h to 122.9 km/h, the cost of operating the second car is less. The first car is most efficient, at 20¢/km, driving at 50 km/h, and the second car is most efficient, at 15¢/km, driving at 55 km/h.

## Chapter 5

### Get Ready, pages 208–209

**1. a)** monomial **b)** binomial **c)** trinomial **d)** trinomial **e)** binomial **f)** trinomial

**2. a)** 5 **b)** 6 **c)** 9 **d)** 5

**3. a)** $7x - 4$ **b)** $-3b - 1$ **c)** $7x^2 + 11x - 1$ **d)** $6y^3 - 2y^2 - 2$ **e)** $15a^2 + a - 19$ **f)** $3c^2 + 6$

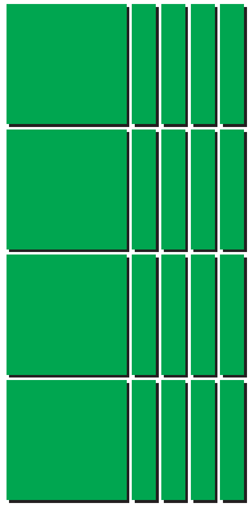
**4. a)** $15x^2 + 2xy - 3y^2$ **b)** $3g^2 + 3gh - 10h^2$ **c)** $8ab^2 + 2a + 5b$ **d)** $cd^2 + 10d$ **e)** $x + 14$ **f)** $-4a^2 + 5b - b^2$

**5. a)**

**b)**

**c)**

**d)**



**6. a)** $21m^2 + 56m$ **b)** $-4c - 36$ **c)** $30a^4 - 40a^3$ **d)** $2d^2 - 4d + 2$

**7. a)** $60x^3 - 12x^2$ **b)** $104x^2 - 16x$

**8. a)** 1, 2, 5, and 10
**b)** 1, 2, 3, 4, 6, 8, 12, and 24
**c)** 1, 2, 4, 8, and 16
**d)** 1, 2, 4, 8, 16, and 32

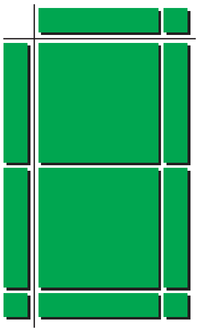
**9. a)** $2 \times 2 \times 2$ **b)** $2 \times 7$ **c)** $2 \times 2 \times 7$ **d)** $2 \times 3 \times 5$

**10. a)** 3 **b)** 5 **c)** 8 **d)** 4 **e)** 3 **f)** 8

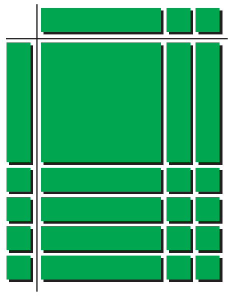
### 5.1 Multiply Polynomials, pages 210–219

**1. a)** $(x + 1)(2x + 3) = 2x^2 + 5x + 3$
**b)** $(x + 1)(x + 3) = x^2 + 4x + 3$
**c)** $(x + 2)(x + 2) = x^2 + 4x + 4$
**d)** $(x + 3)(2x + 1) = 2x^2 + 7x + 3$

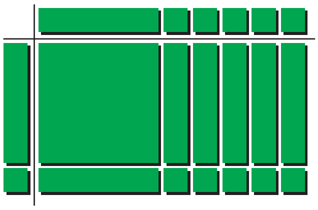
**2. a)**



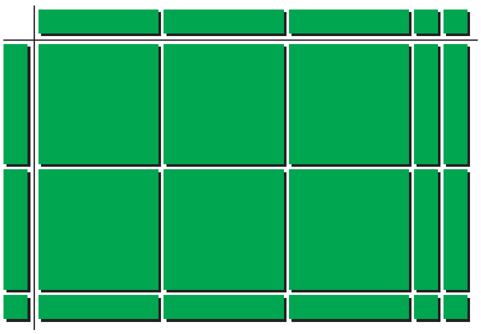
**b)**



**c)**



**d)**



**3. a)** $x^2 + 8x + 15$ **b)** $x^2 + 7x + 12$
**c)** $y^2 + 6y + 8$ **d)** $r^2 + 6r + 8$
**e)** $n^2 + 8n + 7$ **f)** $p^2 + 18p + 81$
**g)** $w^2 + 15w + 56$ **h)** $d^2 + 14d + 33$

**4. a)** $k^2 - 8k + 15$ **b)** $y^2 - 7y + 12$
**c)** $x^2 - 6x + 8$ **d)** $q^2 - 6q + 8$
**e)** $j^2 - 8j + 7$ **f)** $p^2 - 12p + 27$
**g)** $z^2 - 15xz + 56x^2$ **h)** $b^2 - 14bc + 33c^2$

**5. a)** $x^2 - 2x - 15$ **b)** $y^2 - y - 12$
**c)** $c^2 + 2c - 8$ **d)** $w^2 - 2w - 8$
**e)** $m^2 + 6m - 7$ **f)** $y^2 - 6y - 27$
**g)** $x^2 - xy - 56y^2$ **h)** $a^2 - 4ab - 60b^2$

**6. a)** $2x^2 + 11x + 12$ **b)** $5y^2 - 22y + 21$
**c)** $18c^2 + 27c - 5$ **d)** $14w^2 + 3w - 2$
**e)** $25m^2 - 36$ **f)** $18y^2 + 14y - 4$
**g)** $56d^2 - 2cd - 30c^2$ **h)** $42q^2 - 37qr - 60r^2$

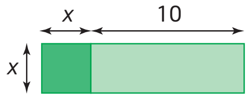
**7. a)** $3x^2 + 3x - 90$ **b)** $-2x^2 + 32x - 126$
**c)** $-y^2 + 6y + 16$ **d)** $2k^2 + 20k + 42$
**e)** $m^3 - 8m^2n + 15mn^2$ **f)** $36a^3 + 90a^2b + 56ab^2$

**8. a)** $2x^2 + 16x + 17$ **b)** $22x^2 - 51x - 233$
**c)** $98x^2 - 51x + 24$ **d)** $5x^2 + 39x + 34$
**e)** $16x$ **f)** $105x^2 + 73x - 46$

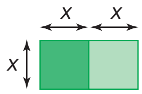
**9. a)** $h = -2d^2 + 36d - 90$ **b)** 70 m

**10. a)** original area: $x^2$ **b)** new area: $(x + 3)(x + 6)$
**c)** $x^2 + 9x + 18$ **d)** increase in area: $9x + 18$
**e)** 126 m$^2$

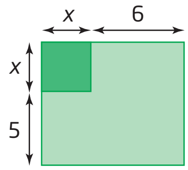
**11. a) i)** Area: $x(x + 10) = x^2 + 10x$



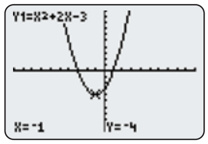

**ii)** Area: $x(2x) = 2x^2$



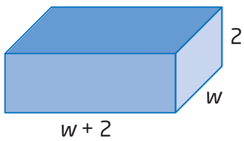

**iii)** Area: $(x + 5)(x + 6) = x^2 + 11x + 30$




**12. a)** $-3, 1$
**b)** $y = x^2 + 2x - 3$
**c)**

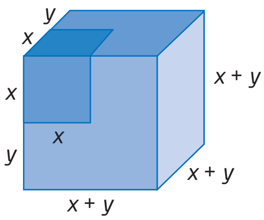



**13. a)**



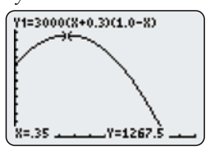

**b)** volume: $(w)(w + 2)(2)$ **c)** $2w^2 + 4w$

**14. a)**




**b)** original surface area: $6x^2$
**c)** new surface area: $6(x + y)^2$
**d)** difference in surface area:
$6(x + y)^2 - 6x^2 = 12xy + 6y^2$
**e)** difference in volume:
$(x + y)^3 - x^3 = 3x^2y + 3xy^2 + y^3$

**15. a)** $-3000v^2 + 2100v + 900$
**b)** 1200 m
**c)** 0.35 m/s



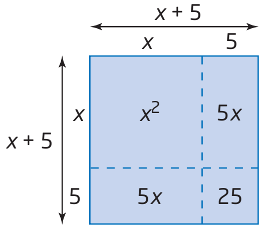

**16.** Methods may vary. For example:
**a)** Area: $4(x + 6) + 5(x) = 9x + 24$
Alternative method:
$(x + 4)(x + 6) - x(x + 1) = 9x + 24$
**b)** Area: $2(3) + x(x + 4)$; $x^2 + 4x + 6$
Alternative method:
$x(x + 7) - 3(x - 2)$; $x^2 + 4x + 6$

**17. a)** $p = 5 - \frac{n}{100}$ **b)** $R = 5n - \frac{n^2}{100}$

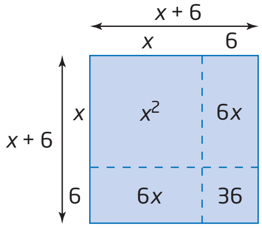
**18.** $s = n^2 - n + 1$, where $s$ is the number of shaded squares and $n$ is the diagram number.
**19.** Answers will vary.
**20.** C

## 5.2 Special Products, pages 220–227

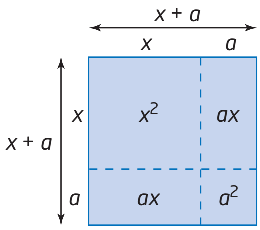
**1. a)**



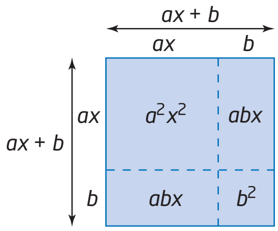

**b)**




**c)**

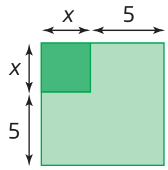



**d)**




**2. a)** $x^2 + 10x + 25$ **b)** $y^2 + 8y + 16$
**c)** $w^2 + 12w + 36$ **d)** $k^2 + 14k + 49$
**e)** $m^2 + 22m + 121$ **f)** $c^2 + 20c + 100$
**g)** $g^2 + 18g + 81$ **h)** $x^2 + 40x + 400$
**3. a)** $x^2 - 10x + 25$ **b)** $z^2 - 6z + 9$
**c)** $x^2 - 18x + 81$ **d)** $c^2 - 2c + 1$
**e)** $v^2 - 24v + 144$ **f)** $b^2 - 200b + 10\,000$
**g)** $n^2 - 4n + 4$ **h)** $m^2 - 12m + 36$
**4. a)** $x^2 + 6xy + 9y^2$ **b)** $4x^2 - 4xy + y^2$
**c)** $25c^2 + 20cd + 4d^2$ **d)** $9a^2 - 24ab + 16b^2$
**e)** $81k^2 + 36km + 4m^2$ **f)** $16u^2 - 40uv + 25v^2$
**5. a)** $v^2 - 1$ **b)** $a^2 - 1$ **c)** $y^2 - 25$ **d)** $x^2 - 49$
**e)** $e^2 - 81$ **f)** $z^2 - 36$ **g)** $x^2 - 144$ **h)** $y^2 - 9$
**6. a)** $w^2 - v^2$ **b)** $9m^2 - n^2$ **c)** $y^2 - 36x^2$
**d)** $9x^2 - 16y^2$ **e)** $49g^2 - 9h^2$ **f)** $81x^2 - 64y^2$
**7. a)** $x^2 - 16$ **b)** $x^2 - 16x + 64$
**c)** $x^2 + 16x + 64$ **d)** $x^2 - 100$
**e)** $x^2 - 121$ **f)** $x^2 + 24x + 144$
**g)** $x^2 - 14x + 49$ **h)** $x^2 - 900$
**8.** $A = \pi(r + k)^2$; $A = \pi r^2 + 2\pi rk + \pi k^2$

**9. a)**




**b)** $x^2 + 10x + 25$
**c)** $10x + 25$

**10. a)** $(-2, 0)$
**b)** $y = x^2 + 4x + 4$
**c)**

$$\begin{aligned} \text{L.S.} &= y \\ &= 0 \end{aligned} \qquad \begin{aligned} \text{R.S.} &= x^2 + 4x + 4 \\ &= (-2)^2 + 4(-2) + 4 \\ &= 4 - 8 + 4 \\ &= 0 \end{aligned}$$

$$\text{L.S.} = \text{R.S.}$$

Therefore, the point $(-2, 0)$ satisfies the equation $y = x^2 + 4x + 4$.

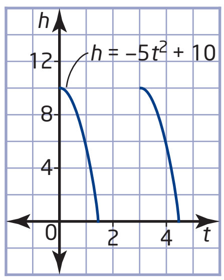
**11. a)** area: $(3x + 2y)(3x - 2y) = 9x^2 - 4y^2$
**b)** change in area: $(3x + 2y)(3x - 2y) - (3x)^2 = -4y^2$
**c)** 476 cm²; 100 cm² less
**12.** Methods may vary. For example: Area: $(x + 2)(x - 2) + (2)(4) = x^2 + 4$
Alternative method: $(x - 2)^2 + (4)(x) = x^2 + 4$
**13. a)**

| Prism | Surface Area of a Side | Surface Area of Top |
|---|---|---|
| bottom | $x(2x + 5)$ | $(2x + 5)^2$ |
| middle | $x(2x + 2)$ | $(2x + 2)^2$ |
| top | $x(2x - 1)$ | $(2x - 1)^2$ |

**b)** $(2x + 5)^2 - (2x + 2)^2 = 12x + 21$
**c)** $(2x + 2)^2 - (2x - 1)^2 = 12x + 3$
**14. a)** $(30 - 1)(30 + 1) = 899$
**b)** $(60 - 1)(60 + 1) = 3599$
**c)** $(100 - 1)(100 + 1) = 9999$
**d)** $(70 - 1)(70 + 1) = 4899$
**15.**

$$\begin{aligned} 32 \times 28 &= (30 + 2)(30 - 2) \\ &= 900 - 4 \\ &= 896 \end{aligned}$$

**a)** $(80 - 4)(80 + 4) = 6384$
**b)** $(30 + 5)(30 - 5) = 875$
**c)** $(100 + 4)(100 - 4) = 9984$
**d)** $(80 - 3)(80 + 3) = 6391$
**16. a)**




**b)** $h = -5(t - 3)^2 + 10$
**c)** $h = -5t^2 + 30t - 35$
**17. a)** $(3264 + x)(2448 + x) = x^2 + 5712x + 7\,990\,272$
**b)** 14.7 megapixels
**19. a)** $x^4 - 8x^3 + 24x^2 - 32x + 16$
**b)** $8x^3 - 14x^2 - 109x - 105$
**c)** $4x^4 + 20x^3 + 37x^2 + 30x + 9$
**d)** $125x^3 - 150x^2 + 60x - 8$

**20. a)** $\Delta E = \frac{1}{2}mv^2 - \frac{1}{2}m(v - 5)^2$

**b)** $\Delta E = \frac{1}{2}mv^2 - \frac{1}{2}m(v - x)^2$

**c)** $\Delta E = 5mv - 12.5m$; $\Delta E = mvx - 0.5mx^2$

**21. a)**

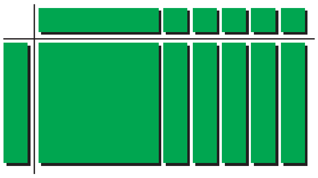
| $n$ | Sum | Formula |
|---|---|---|
| 1 | $1^3 = 1$ | $\frac{1^2(1+1)^2}{4} = 1$ |
| 2 | $1^3 + 2^3 = 9$ | $\frac{2^2(2+1)^2}{4} = 9$ |
| 3 | $1^3 + 2^3 + 3^3 = 36$ | $\frac{3^2(3+1)^2}{4} = 36$ |
| 4 | $1^3 + 2^3 + 3^3 + 4^3 = 100$ | $\frac{4^2(4+1)^2}{4} = 100$ |
| 5 | $1^3 + 2^3 + 3^3 + 4^3 + 5^3 = 225$ | $\frac{5^2(5+1)^2}{4} = 225$ |

**b)**
$$\left[\frac{n(n+1)}{2}\right]^2 = \frac{n^2(n+1)^2}{2^2} = \frac{n^2(n+1)^2}{4}$$

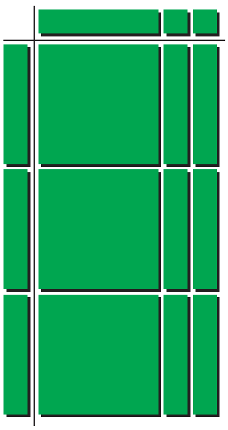
## 5.3 Common Factors, pages 228–235

**1. a)** $x$ **b)** $2a$ **c)** $x^2$ **d)** $k^4$ **e)** $m$ **f)** $-3y^2$

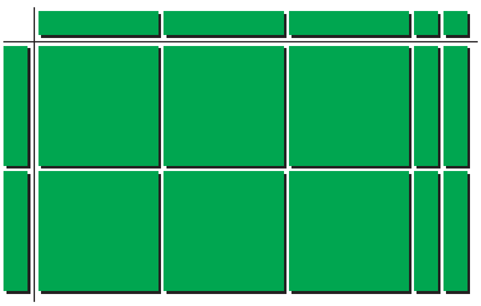
**2. a)**



**b)**



**c)**



**3. a)** $5(3w + 5z)$ **b)** not possible
**c)** $c(17a - 8d)$ **d)** $y(9 - 8y^2)$
**e)** $6b^2(2b^2 + 3)$ **f)** $2(2g^2 - 4g + 3)$
**g)** not possible **h)** $2n^3(n^2 + 6n - 3)$

**4. a)** $2xy(7x + 8y^2)$ **b)** $2k^2m^2(5k - 3)$
**c)** not possible **d)** $22c^2de^2(3c^2 - 1)$
**e)** not possible **f)** $5fg(g - 5 + 4f)$
**g)** $9rs^2(3r - 2r^2 - 4s)$ **h)** $2n^2p^2(2p + 5n^2 - 6n)$

**5. a)** $(x + 8)(3x + 5)$ **b)** $(b + 1)(a + 9c)$
**c)** not possible **d)** $(r + u)(4s - t)$

**6. a)** $(x + y)(m + 2)$ **b)** $(x + 3)(x + 2)$
**c)** $(y + 3)(ay + 4)$ **d)** $(2x + 3)(3x - 1)$
**e)** $(4v - 3)^2$

**7.** Answers may vary. For example:
**a)** $12x + 18y$ **b)** $x^3 + x^2 + x$
**c)** $5y^2 + 10y^3$ **d)** $2a^2b^3 + 4a^3b^4 + 6a^4b^5$

**8. a)** $P = 2(l + w)$
**b)** $P = 48$ cm. The perimeters are the same using the original and the factored form of the formula because the formulas are equivalent.

**9. a)** $SA = 2\pi r(r + h)$
**b)** $SA = 66\pi$ cm$^2$, or approximately 207.3 cm$^2$. The surface areas are the same using the original and the factored form of the formula because the formulas are equivalent.

**10.** length 1, width $6x^2 + 9x$; length 3, width $2x^2 + 3x$; length $x$, width $6x + 9$; length $3x$, width $2x + 3$

**11. a)** $(y - 7)(-5x + 4)$ **b)** $(x - 1)(5y - 2)$

**12. a)** $(2x - 1)^2 + (2x + 2)^2 + (2x + 5)^2$
**b)** $12x^2 + 24x + 30$
**c)** $6(2x^2 + 4x + 5)$

**13. a)** $8(2x - y)(2x + y)$ **b)** $\pi(R - r)(R + r)$

**14.** $y = x(2x - 3)$; $x$-intercepts are 0 and 1.5.

**15. a)** $\frac{1}{2}(x^2 + 3y^2)$ **b)** $\frac{a}{3}(2a^2 - b)$

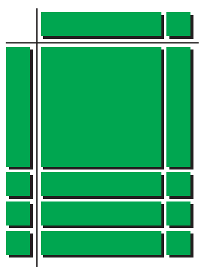
**c)** $\frac{km^2}{6}(k^3 - 3m + 2k)$; you can wait until the last step to divide.

**16.** C

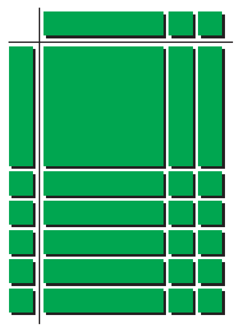
**17.** Let the five consecutive integers be $x$, $x + 1$, $x + 2$, $x + 3$, and $x + 4$. The sum of their squares is
$$\begin{aligned} &x^2 + (x+1)^2 + (x+2)^2 + (x+3)^2 + (x+4)^2 \\ &= x^2 + x^2 + 2x + 1 + x^2 + 4x + 4 + x^2 + 6x + 9 \\ &\quad + x^2 + 8x + 16 \\ &= 5x^2 + 20x + 30 \\ &= 5(x^2 + 4x + 6) \end{aligned}$$
Therefore, the sum is divisible by 5.

## 5.4 Factor Quadratic Expressions of the Form $x^2 + bx + c$, pages 236–241

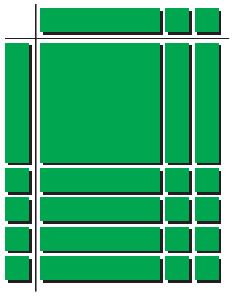
**1. a)**



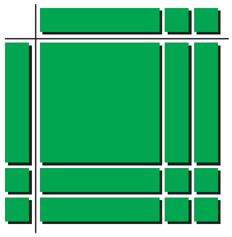
**b)**



c)



d)



**2. a)** 9, 5 **b)** −3, −2 **c)** 5, −2 **d)** −10, 2

**3. a)** $(x + 5)(x + 2)$ **b)** $(j + 9)(j + 3)$
**c)** $(k + 4)(k + 1)$ **d)** not possible
**e)** not possible **f)** $(d + 6)(d + 4)$

**4. a)** $(m - 2)(m - 5)$ **b)** not possible
**c)** $(y - 4)(y - 1)$ **d)** $(r - 8)^2$
**e)** not possible **f)** $(q - 9)(q - 1)$

**5. a)** $(a - 5)(a + 2)$ **b)** $(s + 5)(s - 2)$
**c)** $(d - 9)(d + 1)$ **d)** not possible
**e)** $(g - 7)(g + 2)$ **f)** not possible
**g)** $(x + 7)(x - 6)$ **h)** not possible

**6. a)** $A = (x + 10)(x + 8)$; length 25 cm, width 23 cm
**b)** $A = (x - 5)(x - 10)$; length 10 cm, width 5 cm

**7. a)** $3(x + 3)(x + 1)$ **b)** $2(d - 7)(d - 4)$
**c)** $5(z + 6)(z + 2)$ **d)** $4(s - 4)(s + 2)$
**e)** $b(x + 12)(x - 2)$ **f)** $x(x + 6)(x + 12)$

**8.** Answers may vary. For example:
**a)** 8, 7 **b)** 5, 4 **c)** 7, 2 **d)** 9, 3

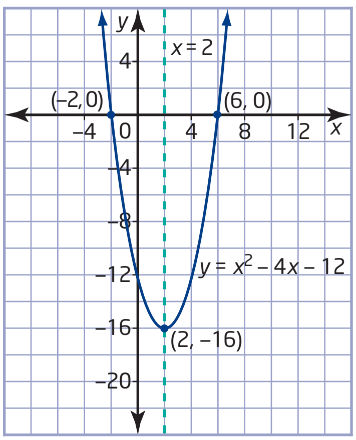
**9.** Answers may vary. For example:
**a)** 5, 9 **b)** −2, −6 **c)** 9, 20 **d)** 3, 8

**10. a)** $x^2 + 4x + 3$; $x^2 + 4xy + 3y^2$
**b)** $x^2 - 2x - 24$; $x^2 - 2xy - 24y^2$
**c)** $x^2 + 7x - 18$; $x^2 + 7xy - 18y^2$
**d)** $x^2 - 15x + 54$; $x^2 - 15xy + 54y^2$
The coefficients of corresponding terms in the simplified forms are the same.

**11. a)** $(a + 8b)(a + 3b)$ **b)** $(k - 9m)(k - 2m)$
**c)** $(c + 7d)(c - 3d)$ **d)** $(x - 8y)(x + 2y)$

**12. a), b)** Answers will vary.

**13. a)** $y = (x - 6)(x + 2)$ **b)** 6, −2
**c)** $x = 2$, (2, −16)




**14. a)** $h = -5(t + 1)(t - 4)$
**b)** The binomial factors can be used to find the $t$-intercepts, one of which represents when the ball will land on the ground.

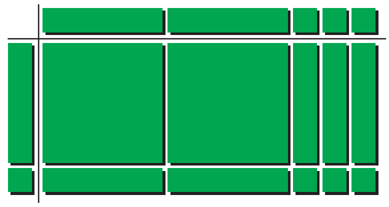
**15. a)** They are alike because the coefficients are the same. They are different because the degrees of the variables are different.
**b)** $(x^2 + 5)(x^2 + 4)$

**16. a)** $(x^2 + 5)(x^2 + 6)$ **b)** $(x^2 - 3y)(x^2 - 4y)$
**c)** $(x^3 - 9)(x^3 + 6)$ **d)** $3(x + 6)(x - 7)$

**17. a)** $x^3 + 6x^2 + 12x + 8$ **b)** $(x + 3)^3$
**c)** $(2a + 5b)^3$

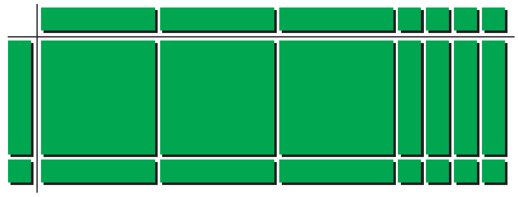
### 5.5 Factor Quadratic Expressions of the Form $ax^2 + bx + c$, pages 242–247

**1. a)**



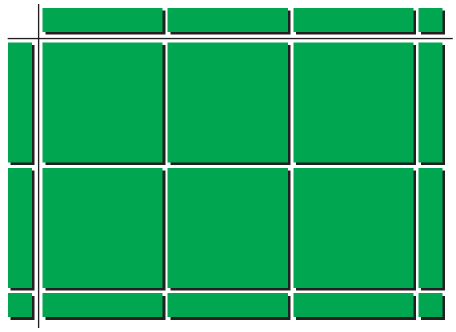
$(x + 1)(2x + 3)$

**b)**



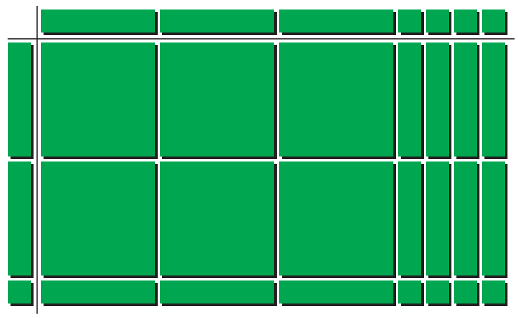
$(x + 1)(3x + 4)$

**c)**



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

**d)**



$(2x + 1)(3x + 4)$

**2. a)** $(2x + 5)(x + 1)$ **b)** $(3y + 8)(2y + 1)$
**c)** $(4k + 3)(k + 3)$ **d)** $(3m + 4)(m + 2)$
**e)** not possible **f)** $(3q + 2)(4q + 3)$

**3. a)** $(x - 2)(4x - 3)$ **b)** $(5n - 6)(n - 1)$
**c)** not possible **d)** $(6a - 1)(a - 1)$
**e)** $(3b - 1)(3b - 7)$ **f)** $(5k - 3)(3k - 2)$

4. a) $(3y + 7)(y - 1)$ b) $(2m - 3)(m + 3)$
c) $(2k + 1)(4k - 5)$ d) $(4y - 1)(3y + 1)$
e) not possible f) $(5h + 1)(h - 3)$

5. a) $(3x + y)(x + 2y)$ b) $(6m + n)(m + 2n)$
c) $(2p - q)(p - 5q)$ d) $(c - 2d)(6c + 5d)$
e) $(3x + y)(3x - 4y)$ f) $(2d - e)(3d + 2e)$

6. a) $2(2k - 1)(2k - 3)$ b) $3(3p - 1)(p + 2)$
c) $2(3m + 2)(m - 3)$ d) $5(2x - 1)(x + 2)$
e) $2(5r - 1)(r - 2)$ f) $2(4y - 3)(y - 2)$

7. a) $(2x + 1)(2x + 5)$; 45 b) $(7x - 2)(x - 3)$; $-12$
c) $(3x + 2)(5x - 4)$; 48 d) $2(4x - 1)(x + 2)$; 56
e) $(2x - 3)(3x - 5)$; 1 f) $(5x + 3)(x + 3)$; 65
The results are the same because the expressions are equivalent.

8. Answers may vary. For example:
a) 17, 8 b) 28, 20 c) 13, 23

9. Answers may vary. For example:
a) $-44$, $-28$ b) 24, $-60$ c) 56, 81

10. If there are two integers whose product is $a \times c$ and whose sum is $b$, then $ax^2 + bx + c$ can be factored over the integers.

11. There will not be as many factors to check.

12. a) $(3x + 8)(2x - 1)$; length $(3x + 8)$, width $(2x - 1)$
b) $P = 114$ cm; $A = 722$ cm$^2$

13. $h = -(5t + 2)(t - 5)$; 5 s

14. a) $r = -0.0008(p - 1000)(p - 3000)$
b) $1000 \leqslant p \leqslant 3000$
c) 2000

15. Answers may vary. For example: number sold: $20 - x$, price per jacket: $36 + 2x$; or number sold: $40 - 2x$, price per jacket: $18 + x$

17. a) $(5x^2 + 3)(x^2 + 3)$
b) $(7x^2 - 6y^2)(x^2 - y^2)$
c) $(3x^3 + 8y^3)(2x^3 - y^3)$
d) $(5m^3 + 4n^2)(2m^3 - 3n^2)$

18. a) $(2x + 2a + 1)(x + a + 1)$
b) $(2x - 2b + 1)(x - b + 2)$

19. a) Answers may vary. For example: The shape could be a rectangle with dimensions $(2x - 1)$ and $(4x + 7)$, a parallelogram with base $(2x - 1)$ and height $(4x + 7)$, or a triangle with base $(4x - 2)$ and height $(4x + 7)$ or base $(2x - 1)$ and height $(8x + 14)$.
b) The shape is a square-based prism with side length $(2x - 3y)$ and height $x$.

## 5.6 Factor a Perfect Square Trinomial and a Difference of Squares, pages 248–255

1. a) $(x + 4)(x - 4)$ b) $(y + 10)(y - 10)$
c) $9(k + 2)(k - 2)$ d) $(2a + 11)(2a - 11)$
e) $(6w + 7)(6w - 7)$ f) $(12p + 1)(12p - 1)$
g) $(4n + 5)(4n - 5)$ h) $(10g + 9)(10g - 9)$

2. a) $(m + 7n)(m - 7n)$ b) $(h + 5d)(h - 5d)$
c) $(10 + 3c)(10 - 3c)$ d) $(13a + 7b)(13a - 7b)$
e) $(5x + 6y)(5x - 6y)$ f) $(4c + 3d)(4c - 3d)$
g) $2(9 + 2s)(9 - 2s)$ h) $3(5h + 3g)(5h - 3g)$

3. a) $x^2 + 12x + 36 = (x)^2 + 2(x)(6) + (6)^2$; $(x + 6)^2$
b) $k^2 + 18k + 81 = (k)^2 + 2(k)(9) + (9)^2$; $(k + 9)^2$
c) $y^2 - 6y + 9 = (y)^2 - 2(y)(3) + (3)^2$; $(y - 3)^2$
d) $m^2 - 14m + 49 = (m)^2 - 2(m)(7) + (7)^2$; $(m - 7)^2$
e) $x^2 + 20x + 100 = (x)^2 + 2(x)(10) + (10)^2$; $(x + 10)^2$
f) $64 - 16r + r^2 = (8)^2 - 2(8)(r) + (r)^2$; $(8 - r)^2$

4. a) $4c^2 + 12c + 9 = (2c)^2 + 2(2c)(3) + (3)^2$; $(2c + 3)^2$
b) $16k^2 - 8k + 1 = (4k)^2 - 2(4k)(1) + (1)^2$; $(4k - 1)^2$
c) $25x^2 + 70x + 49 = (5x)^2 + 2(5x)(7) + (7)^2$; $(5x + 7)^2$
d) $9y^2 - 30y + 25 = (3y)^2 - 2(3y)(5) + (5)^2$; $(3y - 5)^2$
e) $100c^2 - 180c + 81 = (10c)^2 - 2(10c)(9) + (9)^2$; $(10c - 9)^2$
f) $25 + 80y + 64y^2 = (5)^2 + 2(5)(8y) + (8y)^2$; $(5 + 8y)^2$

5. Answers may vary. For example:
a) $y$ is not squared.
b) 107 is not equal to 2(6)(9).
c) 10 is not a perfect square.
d) The expression is a sum of squares, not a difference of squares.

6. a) $(2x + 7y)^2$ b) $(3k - 4m)^2$
c) not possible d) not possible
e) $2(a - 7b)^2$ f) $4(7n + 6m)(7n - 6m)$
g) not possible h) $4(5f - 3g)^2$
i) $100p(2p + 3q)(2p - 3q)$

7. a) area: $(2x + 5)^2 - (x - 3)^2$ b) $(3x + 2)(x + 8)$

8. a) 22, $-22$ b) 20, $-20$
c) 42, $-42$ d) 25
e) 25 f) 11, $-11$

9. Answers may vary. For example:
a) 4, 9 b) 1, 25 c) 16, 25

10. a) $(3ab - 4cd)^2$ b) $(20 + x)(10 - x)$
c) $(6c)(4)$ d) not possible

11. The figure could be a square or a parallelogram with base equal to height.

12. a) $x(x - 1)^2$; height $x$, length $x - 1$, width $x - 1$
b) The box is a square-based rectangular prism, so the top and bottom are squares with area $(x - 1)^2$ and the four sides are rectangles with area $x(x - 1)$.

13. a) middle: $(2x + 2)^2 - (2x - 1)^2$; bottom: $(2x + 5)^2 - (2x + 2)^2$
b) middle: $(4x + 1)(3)$; bottom: $(4x + 7)(3)$
c) middle: 63 cm$^2$; bottom: 81 cm$^2$

14. a) 7 cm b) $(14\pi r - 49\pi)$ cm$^2$

15. No. $(x - 1)^2 = (x - 1)(x - 1)$, while $x^2 - 1 = (x - 1)(x + 1)$. The two factored expressions are not equivalent. Alternatively, $(x - 1)^2 = x^2 - 2x + 1$, which is not equivalent to $x^2 - 1$.

16. $y = (x - 2)^2$; the vertex is (2, 0).

17. a) $(15 + 11)(15 - 11) = 104$
b) $(37 + 27)(37 - 27) = 640$
c) $(98 + 97)(98 - 97) = 195$
d) $(28 + 22)(28 - 22) = 300$

18. a) $s = (n + 3)^2 - 4$ b) $s = (n + 5)(n + 1)$
c) 165 d) Answers will vary.

19. The figure could be a square-based prism with height $\pi x$ and base side length $2x + 5$ or a cylinder with radius $2x + 5$ and height $x$.

20. a) $(x)(x - 8)$ b) $(x + 2)^2$
c) $(5x^2 + 3y^2)(5x^2 - 3y^2)$ d) $(k + 2)^2(k - 2)^3$
e) $(a^3 + 10)^2$
f) $\left(\frac{y^2}{9} + \frac{x^2}{25}\right)\left(\frac{y}{3} + \frac{x}{5}\right)\left(\frac{y}{3} - \frac{x}{5}\right)$

21. a) 72, $-72$ b) 20, $-20$

**22. a)** $x^2 - 1 = (x - 1)(x + 1)$; $x^3 - 1 = (x - 1)(x^2 + x + 1)$;
$x^4 - 1 = (x - 1)(x + 1)(x^2 + 1)$;
$x^5 - 1 = (x - 1)(x^4 + x^3 + x^2 + x + 1)$

**b)** Answers may vary. For example: $x - 1$ is one of the factors of each of the expressions and the number of terms in the other factor is equal to the degree of the original expression. The terms in the other factor form a sum where the coefficient of each of the terms is one and the terms are the sum of the descending degrees of the variable starting with 1 less than the original expression. The factored form of $x^4 - 1$ does not appear to follow the pattern. When expanded, the last two terms of this factored form result in the expression $x^3 + x^2 + x + 1$, which does follow the pattern.

**c)** $x^6 - 1 = (x - 1)(x^5 + x^4 + x^3 + x^2 + x + 1)$, which is also $(x - 1)(x + 1)(x^2 + x + 1)(x^2 - x + 1)$.

**23. a)** By expanding, $(x - 2)(x^2 + 2x + 4) = x^3 - 8$.
**b)** $(m - 4)(m^2 + 4m + 16)$
**c)** $(3y - 5z^2)(9y^2 + 15yz^2 + 25z^4)$

**24. a)** By expanding, $(a + 10)(a^2 - 10a + 100) = a^3 + 1000$.
**b)** $(k^2 + 6e)(k^4 - 6k^2e + 36e^2)$
**c)** $(7q^4 + 9r^8)(49q^8 - 63q^4r^8 + 81r^{16})$

**25. a)** $a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$
**b)** $(3x - 2y)^4$

**26.** D

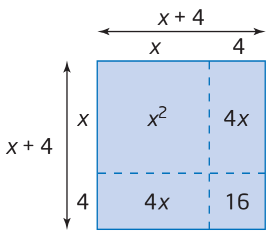
## Chapter 5 Review, pages 256–257

**1. a)** $x^2 + 13x + 40$ **b)** $x^2 - 5x + 4$
**c)** $x^2 - 3xy - 18y^2$ **d)** $10a^2 + 33ab - 54b^2$

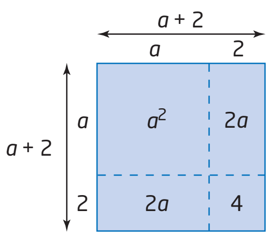
**2. a)** $-k^2 + 5k + 14$
**b)** $w^3 - 10w^2v + 21wv^2$
**c)** $147x^3 + 504x^2y + 189xy^2$
**d)** $2y^2 + 2y$
**e)** $331x^2 + 235x - 204$

**3.** Area: $x(x + 9) + 7(x)$; $x^2 + 16x$

**4. a)**




**b)**

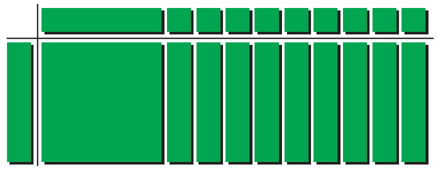



**5. a)** $x^2 + 12x + 36$ **b)** $k^2 + 16k + 64$
**c)** $p^2 + 14p + 49$ **d)** $r^2 - 4r + 4$
**e)** $e^2 - 18e + 81$ **f)** $q^2 - 40q + 400$

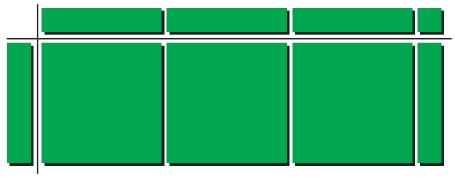
**6. a)** $b^2 - 36$ **b)** $a^2 - 49$
**c)** $y^2 - 144$ **d)** $x^2 - 225$
**e)** $e^2 - 100$ **f)** $x^2 - 36$

**7. a)** $y^2 + 8xy + 16x^2$ **b)** $49m^2 - 14mn + n^2$
**c)** $4c^2 + 36cd + 81d^2$ **d)** $-50x^2 + 98y^2$
**e)** $9a^2 - 64c^2$ **f)** $-25x^2 + 64y^2$

**8. a)**



**b)**



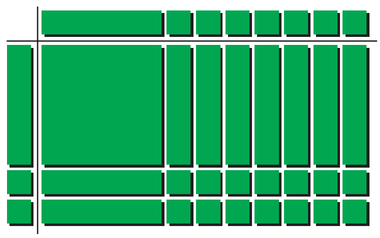
**9. a)** $12(y + 2z)$ **b)** $x(11y - 9z)$
**c)** $c(c + 3)$ **d)** $4k(1 - 2k^2)$

**10. a)** $(m + 3)(4m + 3)$ **b)** $(3k - 2)(3k + 2)$
**c)** $(x + 2)(8x - 5)$ **d)** $(4x - 3y)^2$

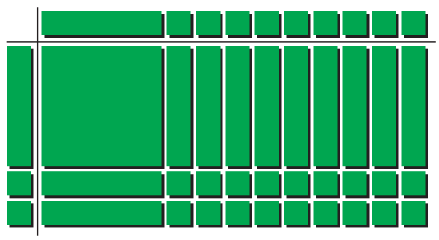
**11. a)** $4(2m^2 - 4m + 1)$ **b)** $2(9c^3 + 12c^2 - 4c + 3)$
**c)** $m(15m - 22n + 66n^2)$ **d)** $az(x^2 - z + x)$

**12.** length$10x^2 + 5x$, width 1; length $2x^2 + x$, width 5; length $10x + 5$, width $x$; length $2x + 1$, width $5x$;

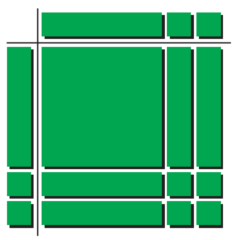
**13. a)**



**b)**

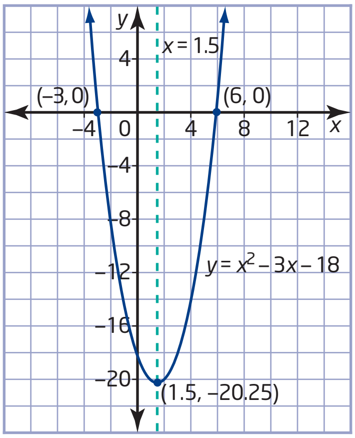


**c)**



**14. a)** $(c - 9)(c - 8)$ **b)** $(x - 3)(x - 5)$
**c)** $(z - 11)(z - 3)$ **d)** $(x + 5)(x - 2)$
**e)** $(x + 9)(x - 1)$ **f)** $(x - 4)(x + 2)$

**15. a)** $y = (x - 6)(x + 3)$ **b)** 6, $-3$
**c)** $x = 1.5$; $(1.5, -20.25)$




**16. a)** $(2x + 3)(x + 2)$ **b)** $(2y + 9)(3y + 1)$
**c)** $(a - 3)(6a - 5)$ **d)** $(4b - 1)(b - 1)$
**e)** $4(3m - 1)(m + 2)$ **f)** $(7k + 2)(2k - 5)$

**17. a)** $(2x + 3y)(4x - 5y)$ **b)** not possible
**c)** $(4m + 3n)(3m + n)$ **d)** not possible
**e)** $3(4x + 3y)(2x - y)$ **f)** not possible

**18. a)** length $4x - 5$, width $2x + 3$
**b)** $P = 140$ cm, $A = 1161$ cm$^2$

**19. a)** $(x + 7)(x - 7)$ **b)** $(y + 11)(y - 11)$
**c)** $(2k + 3)(2k - 3)$ **d)** $16(1 + 3a)(1 - 3a)$
**e)** $(3w + 5x)(3w - 5x)$ **f)** $(1 + 9p)(1 - 9p)$

**20. a)** $x^2 + 14x + 49 = (x)^2 + 2(x)(7) + (7)^2$; $(x + 7)^2$
**b)** $k^2 + 8k + 16 = (k)^2 + 2(k)(4) + (4)^2$; $(k + 4)^2$
**c)** $y^2 - 10y + 25 = (y)^2 - 2(y)(5) + (5)^2$; $(y - 5)^2$
**d)** $25y^2 - 70y + 49 = (y)^2 - 2(y)(7) + (7)^2$; $(5y - 7)^2$
**e)** $36c^2 - 108c + 81 = 9(4c^2 - 12c + 9) = 9[(2c)^2 - 2(2c)(3) + (3)^2]$; $9(2c - 3)^2$
**f)** $121 + 176y + 64y^2 = (11)^2 + 2(11)(8y) + (8y)^2$; $(11 + 8y)^2$

**21. a)** 120, $-120$ **b)** 49

**22. a)** $(3wx - 4yz)^2$ **b)** $(20 + y)(30 - y)$
**c)** not possible **d)** not possible

### Chapter 5 Practice Test, pages 258–259

**1. a)** $(2x + 3)(x + 3) = 2x^2 + 9x + 9$
**b)** $(x + 3)(x + 4) = x^2 + 7x + 12$

**2. a)** $12x^3 - 20x^2y + 32x^2z$
**b)** $14m^3 - 7m^2 + 12m - 9$

**3. a)** $y^2 + 14y + 45$ **b)** $12x^2 - 13x - 14$
**c)** $36k^2 - 1$ **d)** $w^2 - 16w + 64$
**e)** $16c^2 + 40cd + 25d^2$ **f)** $-318x^2 - 22x + 461$

**4. a)** $d = 0.006s^2 + 0.012s + 0.006$
**b)** The minimum stopping distance is $d = 22.326$ m for both versions of the formula.

**5. a)** $3d^2e(3e + 2d)$ **b)** $5pqr(3pr^2 - 5p^2q + 1)$
**c)** $(x + 6)(3)$ **d)** $(2x + 1)(8x - 3)$

**6. a)** Surface area: $2(3x + 4)^2 + 4(x)(3x + 4)$
**b)** $30x^2 + 64x + 32$
**c)** $2(3x + 4)(5x + 4)$

**7. a)** $(x + 8)(x + 3)$ **b)** $(y - 8)(y - 7)$
**c)** $(n - 10)(n + 9)$ **d)** $(x - 7)^2$
**e)** $(h + 10)(h - 10)$ **f)** $(d + 8)^2$

**8. a)** $3(k + 6m)(k - 2m)$ **b)** $(8y + 3)(y + 2)$
**c)** $(3w - 7)(3w - 1)$ **d)** $(5a + 6)^2$
**e)** $(11w + 12)(11w - 12)$ **f)** $(5x - 6y)(2x + y)$

**9.** If there are two integers whose product is $9 \times 18$ and whose sum is $-10$, then $9x^2 - 10x + 18$ can be factored over the integers.

**10. a)** length $x + 15$, width $x - 2$
**b)** 3

**11. a)** 132, $-132$ **b)** 16
**c)** 36 **d)** 25

**12. a)** Area: $(x + 9)^2 - (x + 5)(x - 5)$
**b)** $2(9x + 53)$
**c)** 232 square units; the results are the same because the expressions are equivalent.

**13. a)** $y = 2x^2 + 24x + 70$ **b)** $y = 2(x + 7)(x + 5)$
**c)** Yes, because the three expressions give the same graph when graphed using a graphing calculator.

**14. a)** height $x$, side of base $3x - 5$, side of base $3x - 5$
**b)** It is a square-based prism, so the top and bottom are squares with side length $3x - 5$ and area $(3x - 5)^2$, and the four sides are rectangles with width $3x - 5$, height $x$, and area $x(3x - 5)$.

**15.** Answers may vary. For example:
**a)** 4, 9 **b)** 1, 25 **c)** 9, 16

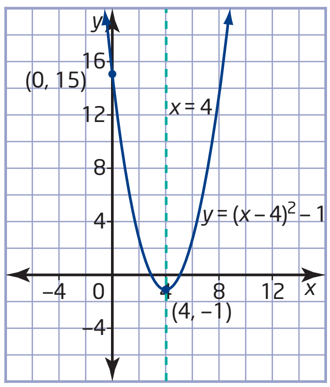
**16. a)** $(34 + 31)(34 - 31) = 195$
**b)** $(127 + 126)(127 - 126) = 253$
**c)** $(52 + 48)(52 - 48) = 400$

**17. a)** The total number of squares, $s$, in diagram $n$ is $s = 4n^2$.
**b)** The total number of shaded squares, $S$, in diagram $n$ is $S = n + 3$.
**c)** The total number of unshaded squares, $u$, in diagram $n$ is $u = 4n^2 - n - 3$.
**d)** $u = (4n + 3)(n - 1)$
**e)** $4(15)^2 - 15 - 3 = 882$ unshaded squares
$(4(15) + 3)(15 - 1) = 882$ unshaded squares

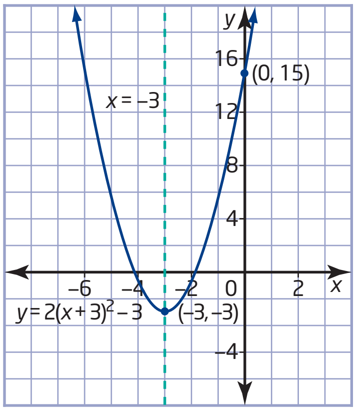
## Chapter 6 Answers

### Get Ready, pages 262–263

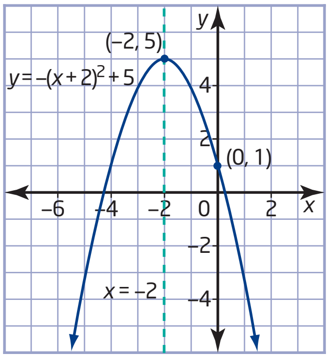
**1. a)**



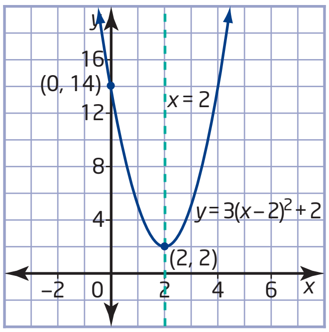
b)



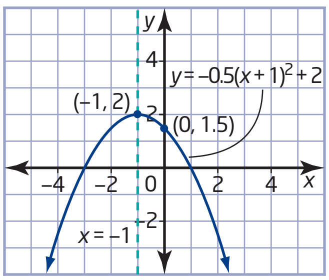

c)



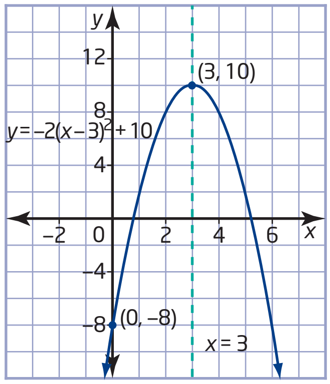

d)



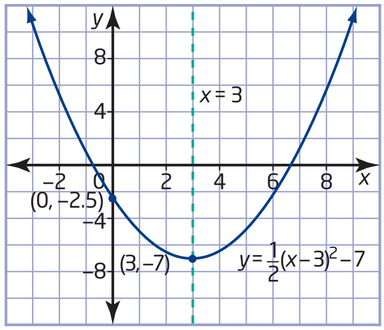

**2. a)**



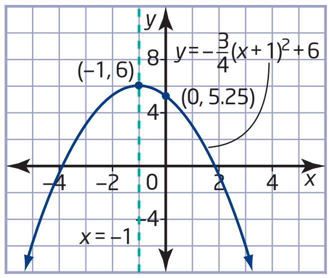

b)




c)




d)




**3. a)** ±10 **b)** ±6 **c)** ±8.7
**d)** not possible

**4. a)** ±3 **b)** ±5 **c)** ±5 **d)** ±7

**5. a)** $2(x + 3)(x + 2)$ **b)** $(x + 14)(x + 2)$
**c)** $(x - 9)(x - 7)$ **d)** $4(x + 3)(x - 3)$
**e)** $(9x + 7)(9x - 7)$ **f)** $3(x - 4)(x + 2)$
**g)** $(4x - 1)^2$ **h)** $(3x + 4)(4x + 1)$

**6. a)** $(x - 8)(x + 4)$ **b)** $2(x + 3)^2$
**c)** $(8x + 1)(8x - 1)$ **d)** $(12x - 13)^2$
**e)** $(7x + 5)^2$ **f)** $(2x + 1)(x - 5)$
**g)** $(3x - 4)(3x - 2)$ **h)** $3(2x + 1)(x + 3)$

**7. a)** The first number is $x$. The second number is $\frac{1}{2}x$.
**b)** The area of the original garden is $A$. The area of the new garden is $3A$.
**c)** The number of price reductions is $n$. The new price, in dollars, is $12 - n$.
**d)** The first number is $x$. The second number is $x^2 + (x + 1)^2$.
**e)** The width is $w$. The length is $2w - 3$.

**8. a)** $x + y = 100$ **b)** $2(l + w) = 50$
**c)** $P = 8w$ **d)** $xy = 4x^2$
**e)** $x + y + 3 = 12$

## 6.1 Maxima and Minima, pages 264–273

**1. a)** $y = (x + 1)^2 + 4$ **b)** $y = (x + 2)^2 + 3$
**c)** $y = (x + 3)^2 - 6$

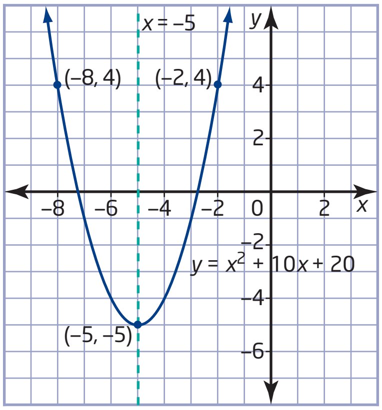
**2. a)** 9 **b)** 49 **c)** 36
**d)** 25 **e)** 1 **f)** 1600

**3. a)** $y = (x + 3)^2 - 10$ **b)** $y = (x + 1)^2 + 6$
**c)** $y = (x + 5)^2 - 5$ **d)** $y = (x + 1)^2 - 2$
**e)** $y = (x - 3)^2 - 13$ **f)** $y = (x - 4)^2 - 18$
**g)** $y = (x - 6)^2 - 28$

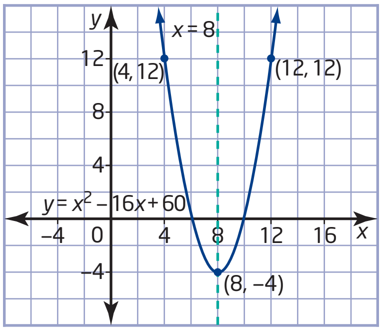
**4. a)** $(-3, -7)$ **b)** $(-6, -6)$ **c)** $(4, -3)$ **d)** $(3, 8)$

**5. a)** D **b)** A **c)** B **d)** C

**6. a)** $(-5, -5)$




**b)** $(8, -4)$

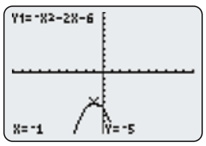



**7. a)** $y = -(x - 40)^2 + 1500$ **b)** $y = -(x + 3)^2 + 13$
**c)** $y = 3(x + 15)^2 - 625$ **d)** $y = 2(x - 4)^2 - 17$
**e)** $y = -7(x - 1)^2 + 4$

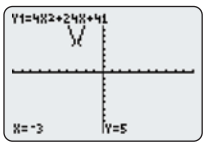
**8. a)** maximum point at $(-5, 16)$
**b)** maximum point at $(7, -1)$
**c)** minimum point at $(-30, -1725)$
**d)** minimum point at $(4, -38)$
**e)** maximum point at $(-20, 1880)$

**9. a)** minimum point at $(-3, -10)$
**b)** minimum point at $(3.8, 3.5)$
**c)** maximum point at $(1.3, -2.3)$
**d)** minimum point at $(0.1, 0.5)$
**e)** maximum point at $(0.8, 23.3)$
**f)** minimum point at $(-0.1, 12.9)$

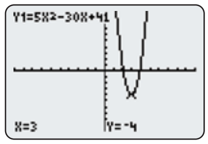
**10. a)** $(-1, -5)$; other points may vary: $(0, -6)$, $(-2, -6)$



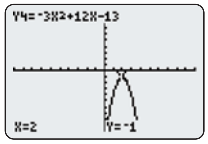

**b)** $(-3, 5)$; other points may vary: $(-2, 9)$, $(-4, 6)$



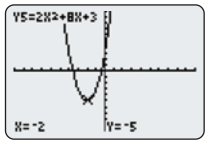

**c)** $(3, -4)$; other points may vary: $(2, 1)$, $(4, 1)$



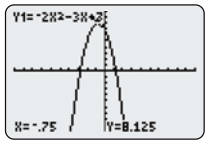

**d)** $(2, -1)$; other points may vary: $(1, -4)$, $(3, -4)$



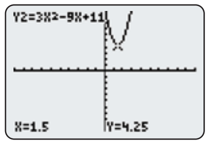

**e)** $(-2, -5)$; other points may vary: $(0, 3)$, $(-3, -3)$



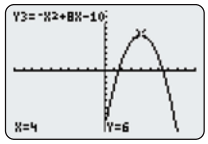

**11. a)** $(-0.75, 8.125)$; other points may vary: $(0, 7)$, $(-1, 8)$



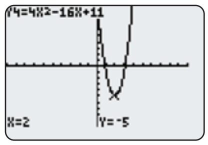

**b)** $(1.5, 4.25)$; other points may vary: $(1, 5)$, $(2, 5)$



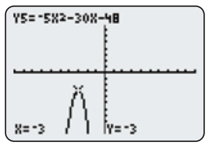

**c)** $(4, 6)$; other points may vary: $(3, 5)$, $(6, 2)$




**d)** $(2, -5)$; other points may vary: $(1, -1)$, $(3, -1)$




**e)** $(-3, -3)$; other points may vary: $(-4, -8)$, $(-2, -8)$




**12.** The maximum height of 5 m occurs at a horizontal distance of 2 m.

**13.** For $h = -4.9t^2 + 10t + 1$, the maximum height of 6.1 m occurs at time $t = 1.0$ s, and for $h = -0.0163x^2 + 0.5774x + 1$, the maximum height of 6.1 m occurs at a horizontal distance of $x = 17.7$ m.

**14.** 4 m

**15.** The minimum cost of $143 occurs when the machine runs for 21 h.

**16. a)** price of a garden ornament: $4 - 0.5x$; number of garden ornaments sold: $120 + 20x$
**b)** $R = (4 - 0.5x)(120 + 20x)$
**c)** $R = -10x^2 + 20x + 480$; $R = -10(x - 1)^2 + 490$; to maximize revenue, the artisan should charge $3.50.
**d)** Both forms produce the same graph.

**17. a)** minimum point at $(-2, -13)$
**b)** maximum point at $(-10, 11)$
**c)** minimum point at $(-5, -7.5)$

**d)** maximum point at (2, 5)
**e)** minimum point at (6, $-6$)
**f)** maximum point at ($-15$, $-4.5$)

**18.** The depth of the half-pipe is 3.2 m.

**19.** **a)** $c = 16$, $h = 4$
**b)** $b = 12$, $h = 6$ or $b = -12$, $h = -6$
**c)** $b = -10$, $c = 27$

**20.** 30 km/h

**21.** No.

**22.** 13.7 h

**23.** $A = 10x - x^2$, where $x$ represents the width of the rectangle. Since the maximum point of the quadratic relation is (5, 25), a 5 cm by 5 cm square will give a maximum area of 25 cm$^2$.

**24.** $A = 200x - 2x^2$, where $x$ represents the width of the field. Since the maximum point of the quadratic relation is (50, 5000), a 50 m by 100 m field will give a maximum area of 5000 m$^2$.

**25.**

| Angle of Elevation | Maximum Height (m) |
|---|---|
| 20° | 0.6 |
| 30° | 1.3 |
| 40° | 2.1 |
| 50° | 3.0 |
| 60° | 3.8 |
| 70° | 4.5 |

**26.** (3, $-4$)

**27.** The relation $y = ax^2 + bc + c$ can be expressed as $y = a\left(x + \frac{b}{2a}\right)^2 - \frac{b^2}{4a} + c$ by completing the square.

Therefore, the $x$-coordinate of the vertex is $-\frac{b}{2a}$.

**28.** $\sqrt{3}R$

**29.** D

**30.** D

## 6.2 Solve Quadratic Equations, pages 274–281

**1.** **a)** $-5$, $-2$ **b)** 3, $-4$ **c)** 1, 7 **d)** 0, $-9$
**e)** $-\frac{3}{2}$, 5 **f)** $\frac{1}{2}$, $-\frac{4}{3}$ **g)** $\frac{5}{3}$, $\frac{3}{4}$

**2.** **a)** $-2$, $-6$ **b)** $-3$, $-6$ **c)** 0, $-3$ **d)** 14, 4
**e)** 0, 2 **f)** 15, 2 **g)** 2, $-11$ **h)** 0, 11

**3.** **a)** $-\frac{1}{3}$, $-9$ **b)** $-1$, $-\frac{15}{4}$ **c)** $\frac{3}{2}$, $\frac{5}{4}$
**d)** $\frac{1}{4}$, $-\frac{1}{4}$ **e)** 0, $-3$ **f)** $\frac{3}{2}$

**4.** **a)** $-1$, $-4$ **b)** $-3$, $-5$ **c)** 12, 1
**d)** $-1$ **e)** 10, $-30$ **f)** 0, 7

**5.** **a)** $-\frac{3}{2}$, $-2$ **b)** 1, $-\frac{8}{9}$ **c)** $\frac{3}{2}$
**d)** $-\frac{1}{2}$, $\frac{5}{8}$ **e)** $\frac{1}{4}$, $-\frac{10}{3}$ **f)** $-\frac{1}{3}$, $-7$

**6.** **a)** $-8$, $-2$ **b)** $-3$, $-5$
**c)** $-1$, $-\frac{3}{2}$ **d)** $\frac{1}{5}$, 3

**7.** 3 m

**8.** 3.5 cm

**9.** **a)** $(x - 5)(x - 4) = 0$
**b)** $(x + 2)(x - 3) = 0$

**10.** **a)** $x^2 + x - 42 = 0$
**b)** The roots remain the same because the quadratic equation is equivalent to $x^2 + x - 42 = 0$ and will have the same factors.

**11.** $15x^2 + 2x - 8 = 0$

**12.** **a), b)** Answers will vary.

**13.** Answers will vary.

**14.** 21 cm and 20 cm

**15.** $n = 0$ will also satisfy the equation. If Chris wants to divide out a common factor, it should not contain any variables. Chris should subtract $15n$ from both sides of the equation, then divide both sides of the equation by 3, and then solve the equation by factoring.

**16.** **a)** For $n = 1$, $S = 1(1 + 1) = 1(2) = 2$. For $n = 2$, $S = 2(2 + 1) = 2(3) = 6$.
**b)** 30 **c)** $n = 17$

**17.** $n = 4$ or 29

**19.** The width is 5 m and the length is 12 m.

**20.** Ralph's shop will lose money during the first 2 years, break even in the third year and make a profit during year 4 and year 5 of operation.

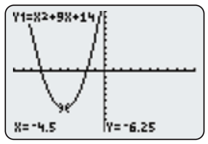
**21.** **a)** $y = -1$, $y = -2$; the coefficients are the same for the equations, but the solution for the equation $y^2 + 3xy + 2x^2 = 0$ is $y = -x$, $y = -2x$.
**b)** **i)** $y = -x$, $y = -2x$ **ii)** $y = 2x$, $y = -\frac{4}{5}x$ **iii)** $y = \frac{3}{2}x$

## 6.3 Graph Quadratics Using the $x$-Intercepts, pages 282–291

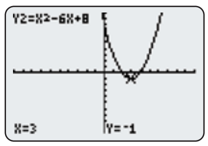
**1.** **a)** $-2$, $-3$ **b)** 7, 4 **c)** 0, $-9$
**d)** 3, $-8$ **e)** 4, $-2$ **f)** 3, $-12$

**2.** **a)** $-\frac{1}{2}$, $-\frac{9}{2}$ **b)** $\frac{3}{4}$, 0 **c)** $\frac{7}{3}$, $-\frac{1}{2}$
**d)** $\frac{4}{5}$, $-2$ **e)** 4, $\frac{1}{3}$ **f)** $\frac{5}{2}$

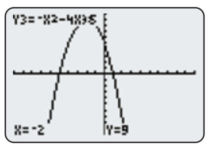
**3.** **a)** $-7$, $-2$; $\left(-\frac{9}{2}, -\frac{25}{4}\right)$



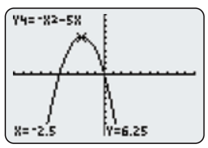

**b)** 4, 2; (3, $-1$)



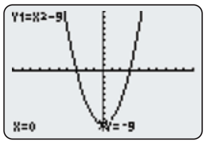

**c)** $-5$, 1; ($-2$, 9)



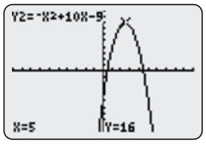

**d)** $-5$, 0; $\left(-\frac{5}{2}, \frac{25}{4}\right)$



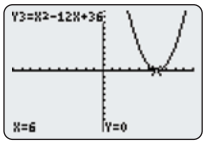
**4. a)** 3, −3; (0, −9)



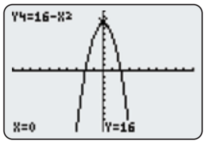

**b)** 1, 9; (5, 16)



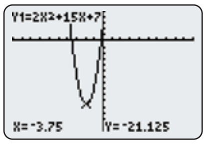

**c)** 6; (6, 0)



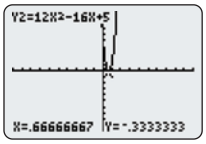

**d)** 4, −4; (0, 16)



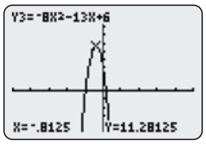

**5. a)** $-\frac{1}{2}, -7; \left(-\frac{15}{4}, -\frac{169}{8}\right)$



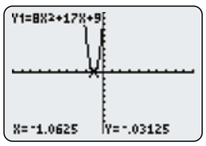

**b)** $\frac{5}{6}, \frac{1}{2}; \left(\frac{2}{3}, -\frac{1}{3}\right)$



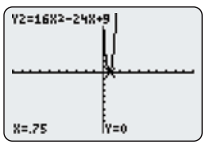

**c)** $-2, \frac{3}{8}; \left(-\frac{13}{16}, \frac{361}{32}\right)$



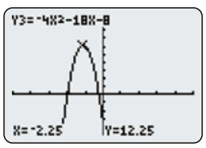

**d)** $-1, -\frac{9}{8}; \left(-\frac{17}{16}, -\frac{1}{32}\right)$




**e)** $\frac{3}{4}; \left(\frac{3}{4}, 0\right)$




**f)** $-4, -\frac{1}{2}; \left(-\frac{9}{4}, \frac{49}{4}\right)$



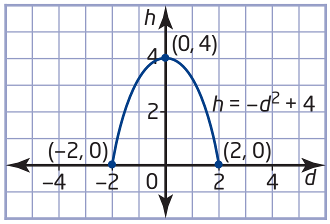

**6. a)** $y = -x^2 + 6x$ **b)** $y = \frac{1}{5}x^2 - \frac{2}{5}x - \frac{24}{5}$

**7. a)** $y = 2x^2 + 20x + 32$ **b)** $y = -\frac{3}{4}x^2 - \frac{9}{2}x - \frac{15}{4}$

**c)** $y = -\frac{1}{2}x^2 + 4x$ **d)** $y = 0.3x^2 - 0.3x - 6$

**8. a)** width 4 m, height 4 m

**b)**

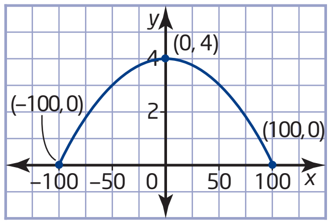



**c)** $-2 \leqslant d \leqslant 2$ so that $h \geqslant 0$.

**9. a)** $-\frac{1}{3}, 4$ **b)** $0 \leqslant x \leqslant 4$

**c)** 4 m **d)** maximum height 14.08 m

**10. a)**

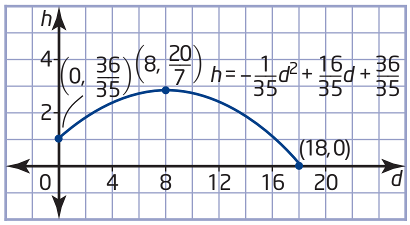



**b)** 1.44 m

**11.** $x$-intercepts −11, 5; $y$-intercept $\frac{385}{64}$

**12. a)** −2, 18

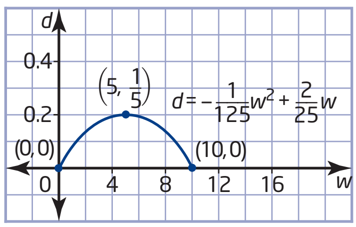
**b)**




**c)** $0 \leqslant d \leqslant 18$ so that $h \geqslant 0$.

**d)** $\frac{36}{35}$ m **e)** 18 m

**13. a)**

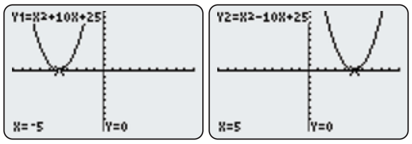



**b)** $0 \leqslant w \leqslant 10$ so that $d \geqslant 0$.

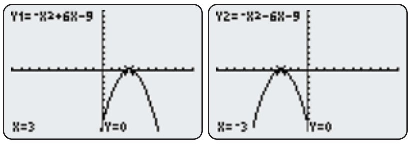
**c)** 10 m **d)** 0.2 m

**14.** If a parabola has only one $x$-intercept, then the vertex is also the $x$-intercept.

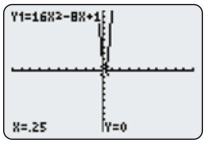
**15. a)** 10, −10




**b)** 6, −6




**c)** 1



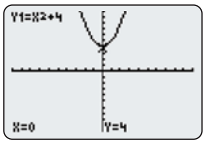

**16. a)** The Marble Heads' marble travels farther by 1.5 m.
**b)** 0 m
**c)** The Marble Heads' marble flies higher.

**17. a)** 6
**b)** Yes, because the width of the airplane hangar decreases as the height increases. If the wings of the Bombardier Canadair CRJ-700 are 2 m above the floor, only five airplanes can fit side by side inside the hangar.

**18. a)** Answers may vary. For example: Parabola A, $y = x^2 - 8x + 18$, Parabola B, $y = -x^2 - 12x - 37$
**b)** Answers may vary. For example: Parabola A and Parabola B do not intersect the $x$-axis and thus do not have $x$-intercepts. Therefore, the equations for these parabolas cannot be factored.

**19.** −33

**20.**




There are no $x$-intercepts for this graph. The vertex of the graph of $y = x^2 + 4$ is (0, 4) and the graph opens upward. The expression $a^2 + b^2$ cannot be factored since the graph of any parabola of the form $y = x^2 + b^2$ does not have any $x$-intercepts and therefore cannot be solved by factoring.

**21. a)** 1, 2 **b)** 3, 4

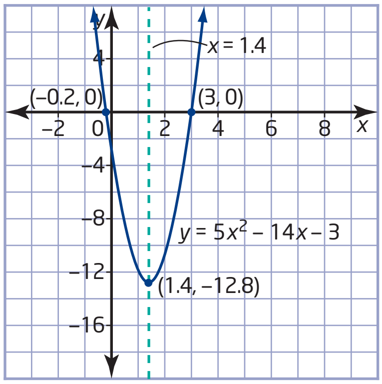
**22. a)** $\frac{3}{8}$ **b)** $\frac{1}{2}$
**c)** The additional information in part b) (John is a boy) changes the situation. For example, only half of the tree diagram of the scenario in part a) needs to be considered.

### 6.4 The Quadratic Formula, pages 292–303

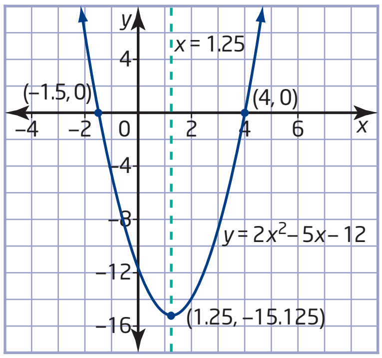
**1. a)** $-3, -\frac{3}{7}$ **b)** $\frac{-4 \pm \sqrt{72}}{4}$
**c)** $\frac{3}{2}$ **d)** $\frac{7 \pm \sqrt{17}}{4}$
**e)** $\frac{-5 \pm \sqrt{37}}{6}$ **f)** $-\frac{3}{4}$

**2. a)** $\frac{-7 \pm \sqrt{34}}{3}$; −0.39, −4.28
**b)** $\frac{-3 \pm \sqrt{7}}{4}$; −0.09, −1.41
**c)** $\frac{7 \pm \sqrt{65}}{8}$; 1.88, −0.13
**d)** $\frac{45 \pm \sqrt{2305}}{20}$; 4.65, −0.15
**e)** $\frac{-16 \pm \sqrt{216}}{-10}$; 0.13, 3.07
**f)** $\frac{17 \pm \sqrt{409}}{12}$; 3.10, −0.27

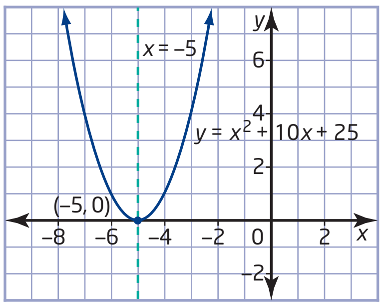
**3. a)** 3, −0.2; (1.4, −12.8); $x = 1.4$



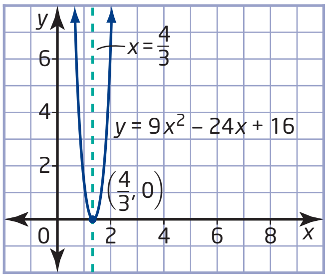

**b)** 4, −1.5; (1.25, −15.125); $x = 1.25$



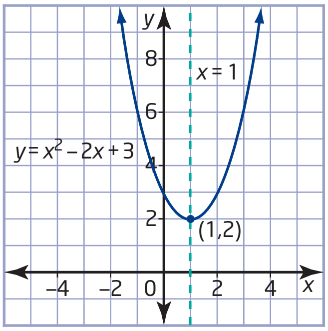

**c)** −5; (−5, 0); $x = -5$



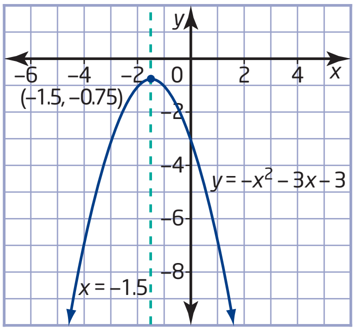
**d)** $\frac{4}{3}$; $\left(\frac{4}{3}, 0\right)$; $x = \frac{4}{3}$




**e)** no $x$-intercepts; (1, 2); $x = 1$




**f)** no $x$-intercepts, $(-1.5, -0.75)$; $x = -1.5$

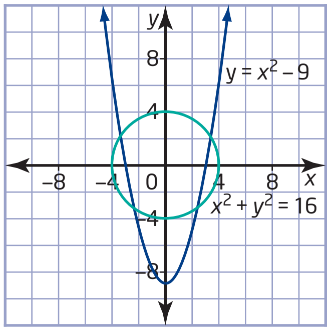



**4. a)** (3, 2); opens upward; no $x$-intercepts
**b)** (2, 4); opens downward; two $x$-intercepts
**c)** $(-4, -5)$; opens upward; two $x$-intercepts
**d)** $(-3, -1)$; opens downward; no $x$-intercepts
**e)** (5, 0); opens upward; one $x$-intercept

**5. a)** $y = x^2 - 6x + 11$; since $b^2 - 4ac < 0$, there are no $x$-intercepts.
**b)** $y = -x^2 + 4x$; since $b^2 - 4ac > 0$, there are two $x$-intercepts, 0 and 4.
**c)** $y = 2x^2 + 16x + 27$; since $b^2 - 4ac > 0$, there are two $x$-intercepts, $\frac{-16 + \sqrt{40}}{4}$ and $\frac{-16 - \sqrt{40}}{4}$.
**d)** $y = -2x^2 - 12x - 19$; since $b^2 - 4ac < 0$, there are no $x$-intercepts.
**e)** $y = x^2 - 10x + 25$; since $b^2 - 4ac = 0$, there is one $x$-intercept, 5.

**6. a)** 10.5 m **b)** 3 m or 7 m
**7. a)** 1.9 s **b)** 5 m
**8.** Answers will vary.
**9. a)** 2.28, $-0.56$ **b)** 0.75, $-4$ **c)** 1.5, $-0.8$
**d)** 2.54, 0.13 **e)** no real roots **f)** $-2.51$, 4.51

**10.** length 139.2 m, height 21.3 m
**11. a)** 0.56 s **b)** 1.09 s **c)** 0.83 s
**12. a)** 8 m **b)** 1.55 m
**13.** 16 m
**14. a)** Since $\sqrt{b^2 - 4ac} = \sqrt{-0.3072}$, there are no $v$-intercepts.
**b)** 100 km/h
**16. a)** $2x^2 - 14x + 7 = 0$ **b)** $3x^2 + 11x - 2 = 0$
**17. a)** 3 **b)** 6, 10, 15
**c)** $\frac{n(n-1)}{2}$ **d)** 46
**18.** Answers may vary. For example: The quadratic equation $x^2 - 6x + 9 = 0$ has $b^2 - 4ac = 0$. When graphed, the quadratic relation $y = x^2 - 6x + 9$ has one $x$-intercept, 3, which is also the vertex, (3, 0), so there is only one real root.
**19.** (3.35, 2.19), $(-3.35, 2.19)$, $(-2.41, -3.19)$, $(2.41, -3.19)$




**20.** The possible numbers of intersection points are 0, 1, 2, 3, and 4; equations will vary.
**21.** $x = \frac{1 \pm \sqrt{5}}{2}$; $x = 1.618$ or $x = -0.618$;

$$\left(\frac{1 - \sqrt{5}}{2}\right)\left(\frac{1 + \sqrt{5}}{2}\right) = \left(\frac{1 - 5}{4}\right) = \left(\frac{-4}{4}\right) = -1$$

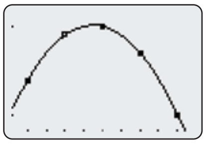
Therefore, the roots of $x = 1 + \frac{1}{x}$ are negative reciprocals.

**22. a)** $\frac{157}{68}$
**b)** converges to the golden ratio, $x = \frac{1 + \sqrt{5}}{2} \doteq 1.618$
**23. a)** 34, 55, 89; each subsequent term is found by adding the two terms before it.
**b)** $x = \frac{1 + \sqrt{5}}{2} \doteq 1.618$ (the golden ratio)
**24.** $a = 2$, $b = 1$, $c = -1$, $d = -2$

## 6.5 Solve Problems Using Quadratic Equations, pages 304–315

**1. a)** $h = -4.9t^2 + 45t + 2$ **b)** 9.23 s
**2. a)** 124 m **b)** $2.79 \leqslant t \leqslant 7.21$
**3.** 1.95 m by 17.95 m
**4.** 57 and 58 or $-57$ and $-58$
**5.** 17 and 19 or $-17$ and $-19$

6. 5 cm, 12 cm, and 13 cm

7. a) 

b) $y = -0.05x^2 + 0.95x + 0.5$

8. 40 mm

9. 46 mm

10. 13 and 14 or −13 and −14

11. 5.5 cm by 6 cm

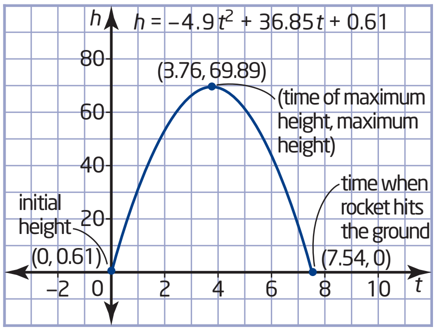
12. 300 m by 600 m

13. 6 units, 8 units, and 10 units

14. 5.97 m

15. a) $h = -4.9t^2 + 36.85t + 0.61$

b) Answers may vary. For example: Use a graphing calculator to calculate the total time in the air. When the height is equal to zero, the time is 7.54 s, to the nearest hundredth. Use a graphing calculator to calculate the maximum height of the rocket. When the time is 3.76 s, the height of the rocket is 69.89 m, to the nearest hundredth.

c) 


16. a) $h = -4.9t^2 + 15t + 1$ b) 11.1 m c) 3.1 s

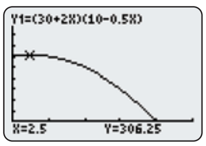
d) The maximum height of 12.5 m occurs at 1.5 s.

e) $h = -0.81t^2 + 15t + 1$; 15.2 m; 18.6 s; the maximum height of 70.4 m occurs at 9.3 s.

f) $h = -11.55t^2 + 15t + 1$; 4.5 m; 1.4 s; the maximum height of 5.9 m occurs at 0.6 s.

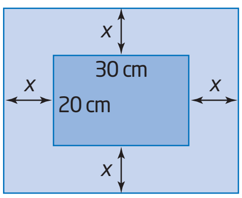
17. a) A model for Sherri's revenue, $R$, in dollars, is $R = (30 + 2x)(10 - 0.5x)$, where $x$ represents the number of \$0.50 price reductions.

b) \$2.50 c) \$8.75 d) \$0

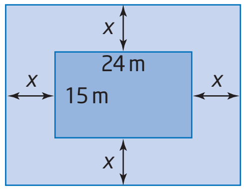
e) 


Part b) is represented by the point (15, 150). Part c) is represented by the vertex (2.5, 306.25), which is the maximum point. Part d) is represented by the $x$-intercept 20.

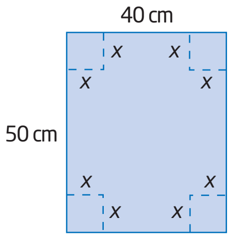
18. 28 cm by 38 cm




19. 28.2 m by 19.2 m



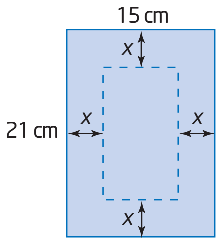

20. 22 m by 68 m

21. a) 

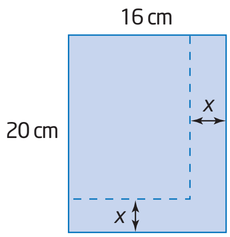

b) 7.5 cm

c) 6562.5 $cm^3$

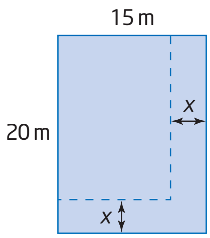
22. 1.5 cm



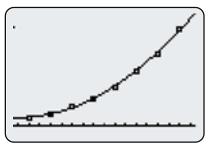

23. 4 cm




24. 10 m by 15 m




25. Answers will vary. For example: $y = \frac{23}{90\,000}x^2 - 23$

26. a) 

b) $y = 0.008x^2 - 0.383x + 8.726$

c) 63.4 m

d) 81 km/h, 111 km/h, 180 km/h

e) Answers may vary. For example: The model does not make sense for speeds less than 24.5 km/h because the stopping distances should be less when the car is going slower.

**27. a)** one point of intersection because the resulting equation is linear
**b)** no points of intersection because the resulting quadratic equation does not have any real roots
**c)** one point of intersection because the resulting quadratic equation has two equal real roots

**28. a)** $WC = 0.0032w^2 - 0.425w + 6$, where $WC$ represents the wind chill temperature and $w$ represents the wind speed.
**b)** The QuadReg operation results in a linear relation, since the coefficient of the $x^2$-term is 0. $WC = t - 13$, where $WC$ represents the wind chill temperature and $t$ represents the air temperature.
**c)** Answers may vary. For example: The wind chill model from part b) is very good, because the data follow a linear model exactly. The model from part a) is quite good because the result for $w = 60$ is very close to the actual result.

**29.** Answers will vary.

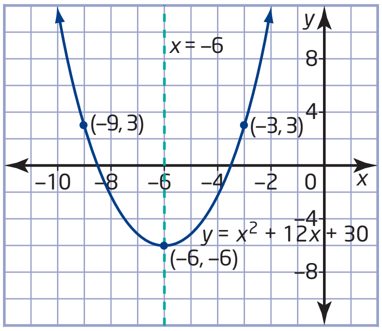
**30.** Answers may vary. For example: Solving two equations in two unknowns results in an approximate quadratic model $y = -\frac{10}{121}(x - 11)^2 + 14$. Therefore, the pumpkin was at a height of 10 m at horizontal distances of 4 m and 18 m.

**31.** $f_1 = 1, f_2 = 1, f_3 = 2, f_4 = 3, f_5 = 5$

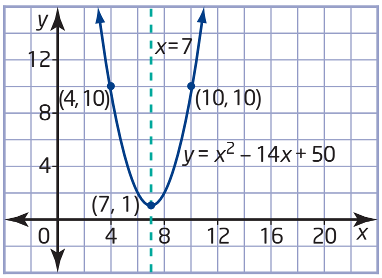
## Chapter 6 Review, pages 316–317

**1. a)** $y = (x + 4)^2 - 23$ **b)** $y = (x + 1)^2 + 6$
**c)** $y = (x + 2)^2 + 2$ **d)** $y = (x + 3)^2 - 12$

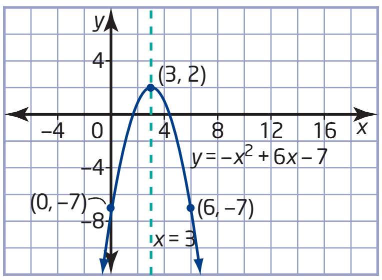
**2. a)** $(-6, -6)$



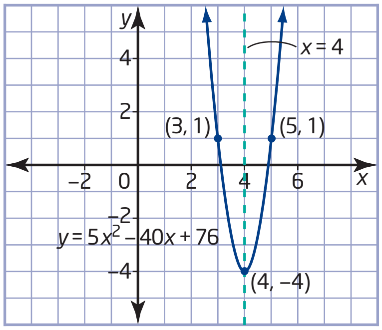

**b)** $(7, 1)$




**c)** $(3, 2)$




**d)** $(4, -4)$



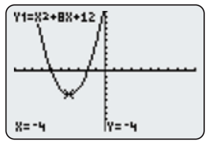

**3. a)** minimum point at $(0.6, 7.3)$
**b)** maximum point at $(0.2, -200.1)$
**c)** minimum point at $(0.2, 0.6)$

**4. a)** $-3, -7$ **b)** $2, -10$ **c)** $-\frac{1}{2}, -3$ **d)** $\frac{2}{5}, -3$

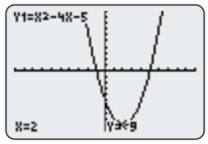
**5. a)** $9, -1$ **b)** $7, 1$ **c)** $-1, -\frac{7}{3}$ **d)** $\frac{3}{5}$
**e)** $\frac{5}{4}, \frac{1}{2}$ **f)** $-\frac{2}{3}, -1$

**6.** 12 cm, 35 cm, 37 cm

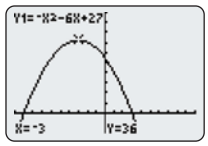
**7. a)** $-2, -6; (-4, -4)$



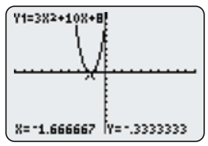

**b)** $-1, 5; (2, -9)$



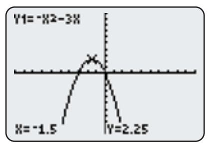

**c)** $-9, 3; (-3, 36)$



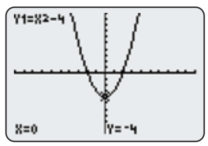

**d)** $-\frac{4}{3}, -2; \left(-\frac{5}{3}, -\frac{1}{3}\right)$




**e)** $-3, 0; \left(-\frac{3}{2}, \frac{9}{4}\right)$




**f)** $2, -2; (0, -4)$



**8.** They will have the same axis of symmetry because it will pass through the midpoint of the line segment connecting the $x$-intercepts, or zeros, but the vertex can be different because vertical stretching or compressing will change the $y$-coordinate of the vertex but not the zeros.

**9. a)** $20, -20$ **b)** $-49$

**10. a)** $-\frac{5}{3}, 1$ **b)** $\frac{4 \pm \sqrt{43}}{9}$

**c)** $\frac{-7 \pm \sqrt{29}}{10}$ **d)** $-\frac{9}{5}$

**11.** 191.4 km/h

**12. a)** $h = -4.9t^2 + 4t + 3$ **b)** 1.29 s

**c)** $0.15 \leqslant t \leqslant 0.66$

**13.** 2.4 m

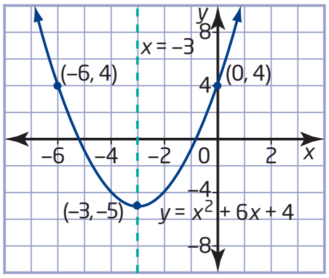
**14. a)** A model for the Sticker Warehouse's revenue, $R$, in dollars, is $R = (6 + x)(4 - 0.25x)$, where $x$ represents the number of \$0.25 price reductions.

**b)** 4 or 6

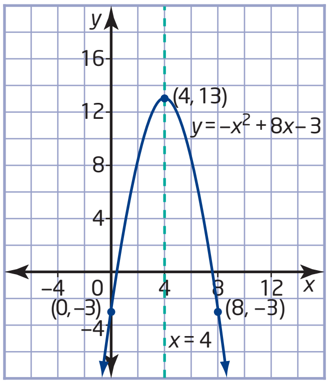
**c)** The maximum revenue of \$30.25 occurs with five price reductions.

### Chapter 6 Practice Test, pages 318–319

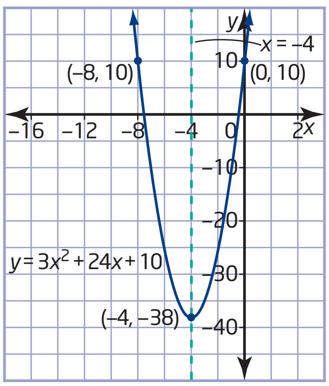
**1. a)**




**b)**




**c)**

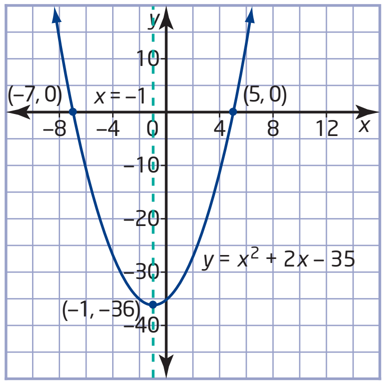



**2. a)** $4, 1$ **b)** $\frac{1}{3}, -\frac{1}{3}$ **c)** $5, -2$ **d)** $\frac{2}{3}$

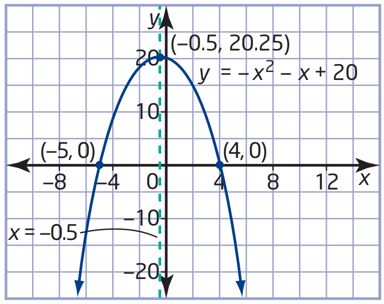
**e)** $\frac{2}{3}, -5$ **f)** $0, -5$ **g)** $0, 2$ **h)** $-\frac{1}{2}$

**3.** Answers may vary. For example: Use factoring to find the $x$-intercepts. Then, find the mean of the $x$-intercepts to find the $x$-coordinate of the vertex. Next, substitute this value into the relation to find the corresponding $y$-coordinate of the vertex. Examples will vary.

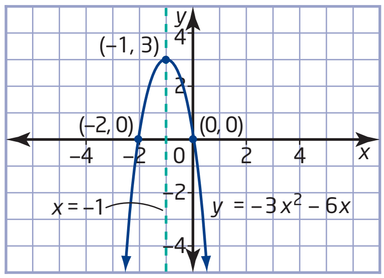
**4. a)** $-7, 5; x = -1; (-1, -36)$



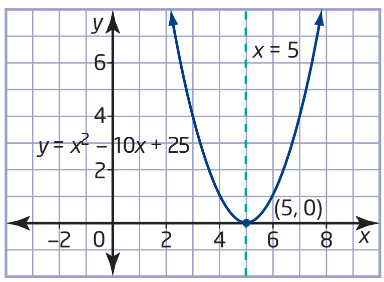

**b)** $-5, 4; x = -0.5; (-0.5, 20.25)$




**c)** $0, -2; x = -1; (-1, 3)$




**d)** $5; x = 5; (5, 0)$



5. **a)** $3, -\frac{1}{4}$ **b)** $\frac{-5 \pm \sqrt{53}}{2}$ **c)** $\frac{5}{3}$

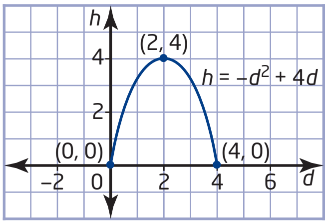
**d)** no real roots **e)** $\frac{9 \pm \sqrt{33}}{8}$ **f)** $\frac{1 \pm \sqrt{85}}{6}$

6. **a)** $\frac{-4 \pm \sqrt{8}}{2}$ **b)** $\frac{8 \pm \sqrt{52}}{2}$ **c)** $\pm\frac{\sqrt{160}}{8}$

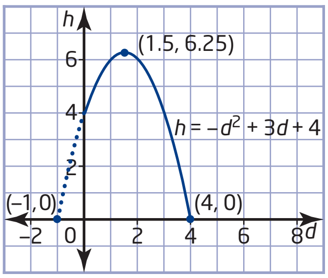
**d)** 1 **e)** 1, 9 **f)** $-1$

**g)** 0, 7 **h)** $\frac{-1 \pm \sqrt{309}}{22}$

7. Answers may vary. For example: The axis of symmetry is the same for both because they have the same value for $a$ and $b$.
8. 21 m
9. **a)** There will be two $x$-intercepts because the parabola opens downward and the vertex is above the $x$-axis.
   **b)** Let $y = 0$, subtract 18 from both sides, and then divide both sides by $-2$. Next, take the square root of both sides before subtracting 1. Finally, simplify the results to find the $x$-intercepts, $-4$ and 2.
   **c)** 6 units
10. **a)** $x^2 - 2x - 15 = 0$
    **b)** $10x^2 - 11x + 3 = 0$
11. **a)** width 4 m, height 4 m
    **b)**



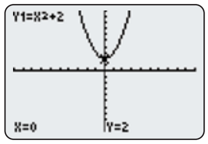

**c)** $0 \leq d \leq 4$ so that $h \geq 0$.
12. The minimum cost of \$246 occurs when the machine runs for 16 h.
13. 6.34 m
14. 50.8 km/h
15. **a)** $-1, 4$
    **b)**




**c)** $0 \leq d \leq 4$ since the relation represents Van's height above the surface of the water.
**d)** 4 m
**e)** 6.25 m
16. **a)** The maximum height of 12.5 m occurs at 1.4 s.
    **b)** 3 s
17. 8 cm, 15 cm
18. 24 cm by 24 cm

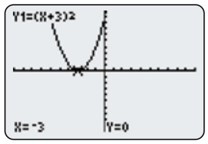
### Chapters 4 to 6 Review, pages 320–321

1. **a)** linear
   **b)** quadratic
2. **a)**



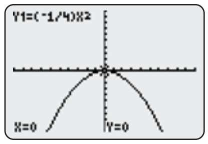

The graph of $y = x^2 + 2$ is the graph of $y = x^2$ translated 2 units upward.

**b)**



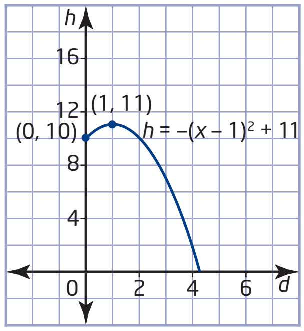

The graph of $y = (x + 3)^2$ is the graph of $y = x^2$ translated 3 units to the left.

**c)**




The graph of $y = -\frac{1}{4}x^2$ is the graph of $y = x^2$ vertically compressed by a factor of $\frac{1}{4}$ and reflected in the $x$-axis.

3. **a)**




**b)** 11 m **c)** 4.3 m
4. $y = \frac{1}{4}(x + 3)(x - 5)$
5. **a)** $\frac{1}{16}$ **b)** $\frac{1}{9}$ **c)** 1 **d)** $\frac{1}{8}$
   **e)** 1 **f)** $\frac{64}{27}$
6. **a)** 1.25 g **b)** 0.156 25 g
7. Answers may vary. For example: Area: $3x(x + 1) + 2x^2$ or $(3x)(2x + 1) - x^2$; $5x^2 + 3x$
8. **a)** $n^2 - 9$ **b)** $h^2 + 10h + 25$
   **c)** $d^2 - 6d + 8$ **d)** $m^2 + 10m + 21$
   **e)** $9t^2 - 25$ **f)** $x^2 - 14x + 49$
9. **a)** $6x^3 - 13x^2 - 5x$ **b)** $3k^2 + 12k + 13$
   **c)** $24y^2 - 79y - 4$ **d)** $18a^2 + 15ab - 18b^2$
10.

| Width | Length |
|---|---|
| 1 | $8x^2 + 4x$ |
| 2 | $4x^2 + 2x$ |
| 4 | $2x^2 + x$ |
| $x$ | $8x + 4$ |
| $2x$ | $4x + 2$ |
| $4x$ | $2x + 1$ |

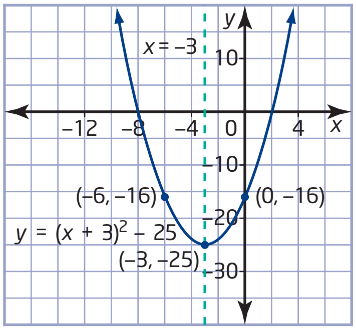
11. **a)** $(y + 9)(y + 3)$ **b)** $(x + 3)(x - 1)$
    **c)** $(n + 21)(n + 1)$ **d)** $(p - 5)(p - 3)$
    **e)** $(x + 5)(x - 3)$ **f)** not possible

**12. a)** $(p + 6)^2$ **b)** $(3d - 1)^2$
**c)** $(x + 7)(x - 7)$ **d)** $(2a - 5)^2$
**e)** $2(2t + 3)(2t - 3)$ **f)** $(a + 2b)(a - 2b)$

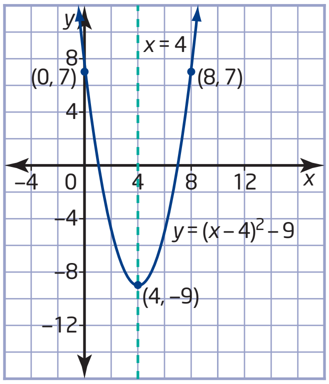
**13. a)** 11, −11, 7, −7 **b)** 12, −12

**14.** $4x + 18$

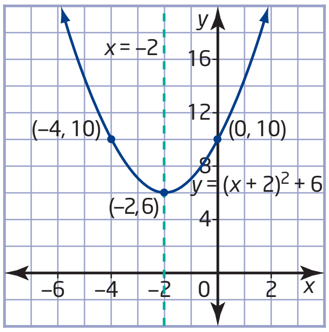
**15. a)** $y = (x + 3)^2 - 25$



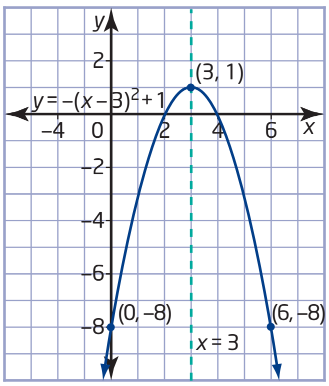

**b)** $y = (x - 4)^2 - 9$



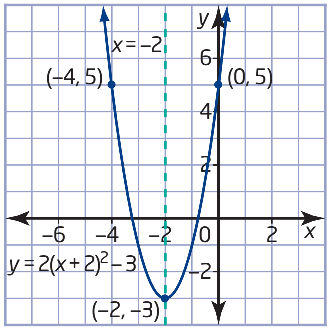

**c)** $y = (x + 2)^2 + 6$



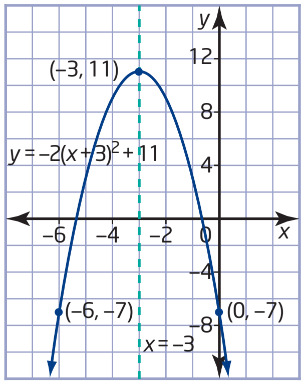

**d)** $y = -(x - 3)^2 + 1$




**e)** $y = 2(x + 2)^2 - 3$

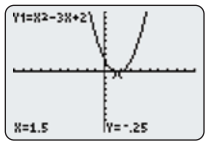



**f)** $y = -2(x + 3)^2 + 11$

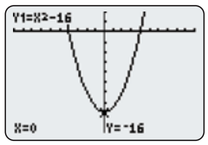



**16. a)** 12, 2 **b)** 3, −7 **c)** 4, − 4
**d)** $-\frac{1}{2}$, −2 **e)** 5

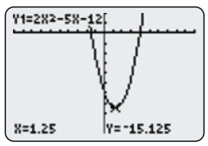
**17. a)** 2, 1; (1.5, −0.25)



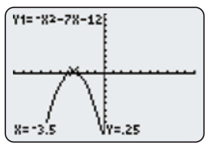

**b)** 4, − 4; (0, −16)



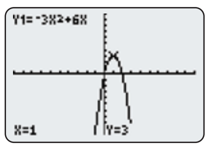

**c)** −1.5, 4; (1.25, −15.125)




**d)** −3, −4; (−3.5, 0.25)




**e)** 0, 2; (1, 3)




**18.** $y = -\frac{4}{9}x^2 - \frac{8}{3}x$

**19. a)** $\frac{6 \pm \sqrt{32}}{2}$ **b)** $\frac{5 \pm \sqrt{13}}{6}$

**c)** $\frac{5.6 \pm \sqrt{122.24}}{6.4}$ or $\frac{7 \pm \sqrt{191}}{8}$

**d)** $\frac{-5 \pm \sqrt{97}}{4}$ **e)** $\frac{8 \pm \sqrt{28}}{6}$

**20.** 0.6 m, 3.4 m

**21.** $22.50

# Chapter 7

## Get Ready, pages 326–329

**1. a)** $c = 25°$, $n = 130°$, $x = 130°$
**b)** $a = 150°$, $y = 30°$, $m = 68°$
**c)** $e = 45°$, $r = 38°$
**d)** $f = 110°$, $u = 70°$, $h = 55°$, $p = 55°$
**e)** $k = 72°$, $v = 36°$

**2.** Answers may vary. For example: The three interior angles of an equilateral triangle are all equal. Let one interior angle be $x$. Since the sum of the interior angles in a triangle is 180°, $x + x + x = 180°$. Then, $3x = 180°$. This equation can be solved to give $x = 60°$. The three equal interior angles in an equilateral triangle are all 60°.

**3.** Answers may vary. For example: Since the sum of the interior angles in a triangle is 180°, $x + y + 90° = 180°$. This equation can be solved to give $x + y = 90°$. The two acute angles in a right triangle are complementary.

**4.** Answers may vary. For example: Let the third interior angle be $c$. Since the sum of the interior angles in a triangle is 180°, $a + b + c = 180°$. This equation can be solved to give $c = 180° - (a + b)$. Since the angles $c$ and $x$ are supplementary, $c + x = 180°$. Substitute the value for $c$ into this equation to get

$$\begin{aligned} 180° - (a + b) + x &= 180° \\ 180° - 180° + x &= a + b \\ x &= a + b \end{aligned}$$

The exterior angle of a triangle is equal to the sum of the two opposite interior angles.

**5. a)** 18.6 cm **b)** 5.3 m

**6. a)** 7.7 m **b)** 7.4 cm

**7. a)** $\frac{2}{3}$ **b)** $\frac{5}{22}$

**8. a)** No. **b)** Yes.

**9. a)** $x = 3$ **b)** $y = 4.5$ **c)** $a = \pm 2$
**d)** $x = -4$ or $x = 2$

**10.** Answers will vary.

**11. a)** 1:100 000 000
**b)** Answers may vary. For example: 900 km; 2200 km
**c)** Answers will vary.

**12. a)** reflection **b)** translation
**c)** dilatation **d)** rotation

**13.** Answers will vary.

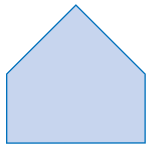
**14.** Answers will vary.

## 7.1 Investigate Properties of Similar Triangles, pages 330–335

**1.** Answers will vary.

**2.** Answers will vary.

**3. a)**



**b)** Answers may vary.

**4.** Answers may vary. For example:
**a)** Congruent figures, because the tiles will be the same, or similar figures if the sides are in proportion.
**b)** Similar figures, because the logo on the shoulder would be smaller than the logo on the chest, but the same shape.
**c)** Neither, because the door would be rectangular and the window might be a square. The figures could also be similar figures, or congruent figures.
**d)** Similar figures, because the three-dimensional model will be smaller than the real building, but the same shape.

**5. a)** $\triangle ABC \sim \triangle KLM$ **b)** $\triangle TJP \sim \triangle RGN$
**c)** $\triangle TVX \sim \triangle UVW$ **d)** $\triangle ABC \sim \triangle EDC$

**6. a)** $\frac{AB}{KL} = \frac{BC}{LM} = \frac{AC}{KM}$ **b)** $\frac{TJ}{RG} = \frac{JP}{GN} = \frac{TP}{NR}$

**c)** $\frac{TV}{UV} = \frac{VX}{VW} = \frac{TX}{UW}$ **d)** $\frac{AB}{ED} = \frac{BC}{DC} = \frac{AC}{EC}$

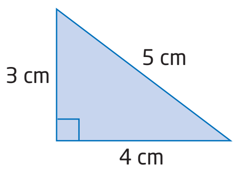
**7. a)** $\triangle PQR \sim \triangle TSR$; $\angle P = \angle T$ and $\angle Q = \angle S$ because they are alternate angles. Also, $\angle PRQ = \angle TRS$ because they are opposite angles.
**b)** $\triangle ABC \sim \triangle ADE$; $\angle A$ is common to both triangles; $\angle B = \angle D$ and $\angle C = \angle E$ because they are corresponding angles of parallel lines.
**c)** $\triangle TUV \sim \triangle WXV$; $\angle V$ is common to both triangles, $\angle U = \angle X$ because they are both right angles. Also, $\angle T = \angle W$ because they are corresponding angles of parallel lines.

**8. a)** $\triangle ABC \sim \triangle DEF$; ratios of corresponding sides are all equal to $\frac{1}{3}$.
**b)** $\triangle DEF \sim \triangle EGF$; ratios of corresponding sides are all equal to $\frac{1}{3}$.
**c)** $\triangle JKM \sim \triangle LJM$; ratios of corresponding sides are all equal to $\frac{1}{2}$.

9. For question 7 a): ∠P = ∠T, ∠Q = ∠S, ∠QRP = ∠SRT; PQ:TS = QR:SR = PR:TR
b) ∠BAC = ∠DAE, ∠B = ∠D, ∠C = ∠E; AB:AD = BC:DE = AC:AE
c) ∠T = ∠W, ∠U = ∠X, ∠TVU = ∠WVX; TU:WX = UV:XV = TV:WV
For question 8 a): ∠A = ∠D, ∠B = ∠E, ∠C = ∠F; AB:DE = BC:EF = AC:DF
b) ∠D = ∠FEG, ∠DEF = ∠G, ∠EFD = ∠GFE; DE:EG = EF:GF = DF:EF
c) ∠KJM = ∠JLM, ∠JKM = ∠LJM, ∠JMK = ∠LMJ; JK:LJ = KM:JM = JM:LM
10. Answers will vary.
11. Answers will vary.
12. **a)** Answers may vary. For example: reflection or translation
**b)** Answers may vary. For example: rotation or dilatation
13. Answers will vary.
14. Answers may vary. For example: Yes, because the corresponding interior angles will be equal (60°) and the ratios of corresponding side lengths will be equal.
15. Answers may vary. For example: No, because the two equal angles in an isosceles triangle may not equal the two equal angles in a different isosceles triangle.
16. Answers may vary. For example: translation
17. **a)** $l = 9.0$ cm, $h = 3.6$ cm, $w = 1.8$ cm
**b)** $l = 27.0$ cm, $h = 10.8$ cm, $w = 5.4$ cm
18. 46.8 kg
19. 48 cm$^2$
20. A

## 7.2 Use Similar Triangles to Solve Problems, pages 342–351

1. **a)**




**b)** 6
**c)** 18 cm, 24 cm
2. **a)** area of first triangle 6 cm$^2$, area of similar triangle 216 cm$^2$
**b)** The area of the larger triangle is 36 times as great as the area of the smaller triangle.
**c)** Answers may vary. For example: 36 is the square of the scale factor, 6.
3. Answers will vary.
4. Answers will vary.
5. **a)** △PQR ~ △STR because ∠RPQ = ∠RST and ∠PQR = ∠STR because they are alternate angles of parallel lines, and ∠PRQ = ∠SRT because they are opposite angles.
**b)** $x = 10$ cm, $y = 18$ cm
6. **a)** $d = 14$ cm, $f = 8$ cm **b)** $s = 6$ cm, $r = 30$ cm
**c)** $b = 7.5$ cm, $w = 6$ cm **d)** $p = 6.75$ cm, $r = 7.5$ cm
**e)** $d = 12.5$ cm, $e = 15$ cm
7. **a)** 8 cm **b)** 9 cm
8. **a)** 128 cm$^2$ **b)** 24 cm$^2$
**c)** 27 cm$^2$ **d)** 25.6 cm$^2$
9. 3.1 m
10. 109 m
11. 44 m
12. **a)** 43.5 cm$^2$ **b)** $10\frac{7}{8}$ cm$^2$; $32\frac{5}{8}$ cm$^2$
**c)** 391.5 cm$^2$ **d)** 29.5 cm
13. **a)** Answers may vary. For example: 16; 10 × 20, 20 × 20, 20 × 40, 20 × 60, 20 × 80, 20 × 100, 20 × 120, 20 × 140, 20 × 160, 40 × 40, 40 × 60, 40 × 80, 40 × 100, 40 × 120, 40 × 140, 40 × 160
**b)** 200 cm$^2$ **c)** 12 800 cm$^2$
**d)** 3200 cm$^2$ **e)** 9600 cm$^2$
14. length 22 m, width 17.4 m
15. Answers will vary.
16. 30 cm
17. Answers may vary. For example: Let the first right triangle have base $b$, height $h$, and area $A_1 = \frac{1}{2}bh$. Then the similar right triangle has base $kb$ and height $kh$, since $k$ is the scale factor that relates the corresponding side lengths. The area of the similar triangle is

$$\begin{aligned} A_2 &= \frac{1}{2}(\text{base})(\text{height}) \\ &= \frac{1}{2}(kb)(kh) \\ &= \frac{1}{2}(k^2)(bh) \\ &= k^2\left(\frac{1}{2}bh\right) \\ &= k^2A_1. \end{aligned}$$

The areas of two similar right triangles are related by the square of the scale factor, $k^2$.
18. **a)** Answers will vary. **b)** Answers will vary.
**c)** Answers may vary. For example: The ratio of the areas of the triangles is $k^2$. $\frac{\text{Area}_{\Delta_1}}{\text{Area}_{\Delta_2}} = k^2$
19. 2:3
20. Answers may vary. For example: Let the first triangle have side lengths $a$, $b$, and $c$. Then, the second triangle has corresponding side lengths of $\frac{3}{5}a$, $\frac{3}{5}b$, and $\frac{3}{5}c$. Then, the two perimeters are

$$\begin{aligned} P_2 &= a + b + c \text{ and} \\ P_1 &= \frac{3}{5}a + \frac{3}{5}b + \frac{3}{5}c \\ &= \frac{3}{5}(a + b + c) \\ &= \frac{3}{5}P_2 \end{aligned}$$

The ratio of the perimeters is $\frac{3}{5}P_2$:$P_2$, or 3:5.
21. Answers will vary.
22. Happy Valley/Goose Bay
24. **a)** 4.8 m **b)** 12
25. 150 km$^2$
26. **a)** Answers may vary. For example: Earth is round and not flat.
**b)** Answers will vary.
27. B
28. 5.76:1
29. $h = \frac{P}{2} - \frac{2A}{P}$
30. 30 m

## 7.3 The Tangent Ratio, pages 352–365

**1. a)** 0.6667 **b)** 0.7292 **c)** 0.4000
**d)** 1.0000 **e)** 0.7500 **f)** 1.8750

**2. a)** 1.5000 **b)** 1.3714 **c)** 2.5000
**d)** 1.0000 **e)** 1.3333 **f)** 0.5333

**3. a)** 2.1445 **b)** 0.2679 **c)** 1.8807
**d)** 0.0875 **e)** 0.5938 **f)** 7.4947
**g)** 0.3739 **h)** 1.0000

**4. a)** 56° **b)** 37° **c)** 31° **d)** 39°
**e)** 40° **f)** 41° **g)** 72° **h)** 59°

**5. a)** $\angle A = 36°$, $\angle C = 54°$ **b)** $\angle M = 51°$, $\angle K = 39°$
**c)** $\angle P = 32°$, $\angle R = 58°$ **d)** $\angle A = 53°$, $\angle C = 37°$

**6. a)** 6.7 cm **b)** 1.0 m **c)** 10.0 mm **d)** 4.1 cm

**7. a)** 11.0 m **b)** 6.0 m **c)** 11.2 m **d)** 11.3 m
**e)** 5.1 m **f)** 13.1 m

**8. a)** 5.2 m **b)** 23.6 m

**9.** $\tan 72° = \frac{w}{12}$; width is 37 m

**10.** 8.8 m

**11.** Rocco's height above the ground: 7 m; Biff's height above the ground: 14 m

**12. a)** 32° **b)** 4.1 min **c)** Answers will vary.

**13.** 12 m

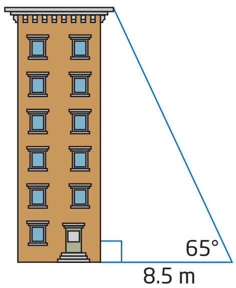
**14.** 55°

**15.** 37°

**16.** $x = 7.0$ m, $y = 6.3$ m

**17.** $x = 8.9$ cm, $y = 45°$

**18. a)** Answers may vary.
**b)** 18.2 m



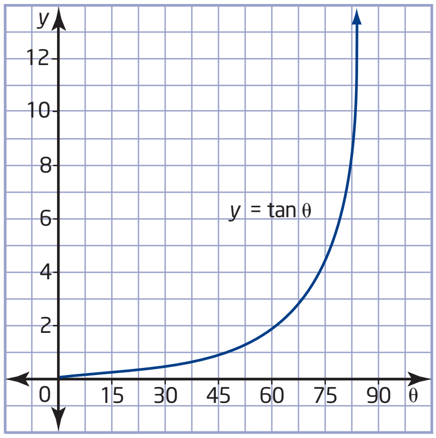

**19. a)** Tables will vary. **b)** $\tan 45° = 1$
**c)** Answers will vary. **d)** Answers will vary.
**e)** Tangents of angles less than 45° are between 0 and 1; tangents of angles greater than 45° and less than 90° are greater than 1; tangents of angles very close to, but not equal to, 90° are very large, and approach infinity.
**f)** Answers may vary. For example: When the angle is less than 45°, the opposite side is shorter than the adjacent side, so the tangent ratio is less than 1. When the angle is greater than 45° but less than 90°, the opposite side is longer than the adjacent side, so the tangent ratio is greater than 1. When the angle gets very close to 90°, the adjacent side gets very small compared to the opposite side, so their quotient becomes very large.

**20. a)** $\tan 0° = 0$; $\tan 90°$ is undefined.
**b)** Answers may vary. For example: When the angle is 0°, the opposite side length is zero, so zero divided by any adjacent length equals 0. When the angle is 90°, the adjacent side length is zero, and any opposite side length divided by 0 is undefined.

**21.** 14°

**22. a)** Answers may vary. For example: He has a slightly larger angle (14.25° compared to 14.04°) being positioned in the middle, but normally a player slaps the puck predominantly in one direction, so positioning in front of a post might be better.
**b)** Answers may vary. For example: If he is directly closer to the net, he has a wider angle to work with, so this would be easier. If he is directly farther from the net, he has less of an angle to work with, so this would be more difficult.

**23. a)** Tables will vary. **b)** Answers will vary.




The relationship is non-linear because the graph is not a straight line.
**c)** Answers will vary. The graph looks like it increases very quickly as it approaches 90°.

**24.** 31°

**25.** 87°

**26. a) i)** $m = 1$ **ii)** $\tan A = 1$ **iii)** The answers are the same. **iv)** $\angle A = 45°$
**b) i)** $m = 2$ **ii)** $\tan B = 2$ **iii)** The answers are the same. **iv)** $\angle B = 63°$
**c) i)** $m = 0.5$ **ii)** $\tan B = 0.5$ **iii)** The answers are the same. **iv)** $\angle C = 27°$

**27.** C

**28.** 15°

## 7.4 The Sine and Cosine Ratios, pages 366–377

**1. a)** $\sin\theta = \frac{4}{5}$, $\cos\theta = \frac{3}{5}$, $\tan\theta = \frac{4}{3}$

**b)** $\sin\theta = \frac{12}{13}$, $\cos\theta = \frac{5}{13}$, $\tan\theta = \frac{12}{5}$

**c)** $\sin\theta = \frac{60}{67}$, $\cos\theta = \frac{30}{67}$, $\tan\theta = 2$

**d)** $\sin\theta = \frac{89}{120}$, $\cos\theta = \frac{2}{3}$, $\tan\theta = \frac{89}{80}$

**e)** $\sin\theta = \frac{4}{9}$, $\cos\theta = \frac{8}{9}$, $\tan\theta = \frac{1}{2}$

**f)** $\sin\theta = \frac{10}{27}$, $\cos\theta = \frac{25}{27}$, $\tan\theta = \frac{2}{5}$

**g)** $\sin\theta = \frac{25}{54}$, $\cos\theta = \frac{8}{9}$, $\tan\theta = \frac{25}{48}$

**h)** $\sin\theta = \frac{11}{17}$, $\cos\theta = \frac{13}{17}$, $\tan\theta = \frac{11}{13}$

2. a) sin A = 0.5778, cos A = 0.8111, tan A = 0.7123
b) sin A = 0.5000, cos A = 0.8667, tan A = 0.5769
c) sin A = 0.7895, cos A = 0.6140, tan A = 1.2857
d) sin A = 0.8333, cos A = 0.5500, tan A = 1.5152
e) sin A = 0.7383, cos A = 0.6711, tan A = 1.1000
f) sin A = 0.7469, cos A = 0.6639, tan A = 1.1250

3. a) 0.5736 b) 0.7071 c) 0.8660
d) 0.6018 e) 0.4226 f) 0.0000
g) 0.9998 h) 0.5000

4. a) 0.1702 b) 0.7071 c) 0.8660
d) 0.5000 e) 0.0175 f) 1.0000
g) 0.9962 h) 0.1219

5. Answers may vary. For example: The results are the same for questions 3 h) and 4 d). sin 30° = cos 60° because the sine and cosine ratios of complementary angles are comparing the same side to the hypotenuse.

6. a) 63° b) 30° c) 30° d) 42°
e) 49° f) 72° g) 45° h) 24°
i) 18° j) 86° k) 7° l) 0°

7. a) 63° b) 51° c) 63° d) 70°
e) 27° f) 78° g) 80° h) 52°
i) 20° j) 89° k) 90° l) 60°

8. a) sin T = 0.4545; 27° b) sin T = 0.2; 12°

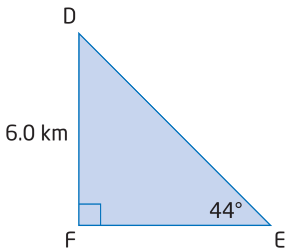
9. a) cos T = 0.5; 60° b) cos T = 0.3; 73°

10. a) 5.5 cm b) 6.1 cm c) 13.1 cm
d) 29.0 cm e) 48.1 cm f) 15.7 cm
g) 18.3 cm h) 27.4 cm

11. a) 37.1 mm b) 8.7 m c) 7.6 cm
d) 13.1 cm e) 8.2 cm f) 12.2 cm
g) 6.3 cm h) 28.6 cm

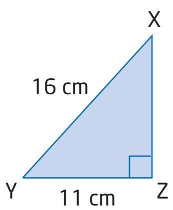
12. a) $\angle$A = 52°, $a$ = 15.4 cm, $b$ = 19.5 cm
b) $\angle$D = 75°, $d$ = 15.5 m, $f$ = 4.1 m
c) $\angle$G = 45°, $\angle$I = 45°, $i$ = 5.1 mm
d) $\angle$J = 70°, $\angle$L = 20°, $k$ = 13.1 cm

13. a)




b) $\angle$D = 46°, $d$ = 6.2 km, $f$ = 8.6 km

14. a)




b) $\angle$X = 43°, $\angle$Y = 47°, $y$ = 11.6 cm

15. a) 38 m b) 12 m

16. a) 0.76°
b) For example: Yes. Explanations may vary. If the rise doubles to 40 m, the angle becomes

$$\tan^{-1}\left(\frac{40}{1.5}\right) = 1.53°, \text{ and } 1.53° \text{ is about double } 0.76°.$$

17. 13.1 cm
18. 56°
19. 35 m
20. 3.6 cm
21. 4.1 m
22. 21.8 cm
23. 9.3 m
24. 22 m
25. $\angle$X = $\angle$Y = 37°, $\angle$W = 106°

26. a) 53°
b) 8 min. Explanations may vary. For example: Use the Pythagorean theorem to find the distance along Orchard Avenue, which is 1.6 km. Walking the total distance of 2.8 km at 6 km/h on Rutherford St. and Orchard Ave. would take 28 min, so Enzo saves 8 min by taking the 20-min shortcut. This assumes that Enzo always walks at the same rate.

27. 34 m. Methods may vary. For example: Use the sine ratio to solve for the hypotenuse length.

28. Answers may vary. For example: The sine and cosine ratios of complementary angles are equal. Also, the sum of the square of the sine ratio of a given angle and the square of the cosine ratio of the same angle is one.

29. Answers may vary. For example:
a) No, because both ratios are with respect to the length of the hypotenuse and since the hypotenuse is always the longest side in a right triangle, the denominator in the ratios will always be larger.
b) Yes, because the length of the opposite side to an angle can be greater than the length of the adjacent side.

30. Minneapolis; 2553 km
32. $x$ = 7.2 cm, $y$ = 10.8 cm
33. $x$ = 7.4 m, $y$ = 38°

34. a)

| Triangle | △ABC | △DEF |
|---|---|---|
| tan $x$ | $\frac{3}{4}$ | $\frac{5}{12}$ |
| sin $x$ | $\frac{3}{5}$ | $\frac{5}{13}$ |
| cos $x$ | $\frac{4}{5}$ | $\frac{12}{13}$ |
| tan (90° – $x$) | $\frac{4}{3}$ | $\frac{12}{5}$ |
| sin (90° – $x$) | $\frac{4}{5}$ | $\frac{12}{13}$ |
| cos (90° – $x$) | $\frac{3}{5}$ | $\frac{5}{13}$ |

b) Answers may vary. For example: tan $x$ and tan (90° − $x$) are reciprocals.
c) Answers may vary. For example: sin $x$ = cos (90° − $x$)
d) Answers may vary. For example: cos $x$ = sin (90° − $x$)
e) Answers may vary. For example: tan $x$ and tan (90° − $x$) are reciprocals because when you look at the complementary angle, the opposite sides and adjacent sides switch places. sin $x$ = cos (90° − $x$) and cos $x$ = sin (90° − $x$) because in each case the opposite and adjacent sides just switch positions.

**35.** Answers may vary. For example: Let θ be an acute angle in a right triangle, oriented so that θ is the angle of elevation. Then, the opposite side is the height and the adjacent side is the base of the triangle. Thus,

$\sin\theta = \dfrac{\text{height}}{\text{hypotenuse}}$. The other acute angle will be

$90° - \theta$, and for this angle, the adjacent side will be the height of the triangle. Thus,

$\cos(90° - \theta) = \dfrac{\text{height}}{\text{hypotenuse}}$, which also equals sin θ.

**36.** Answers may vary. For example:

$$\frac{\sin\theta}{\cos\theta} = \frac{\left(\dfrac{\text{opposite}}{\text{hypotenuse}}\right)}{\left(\dfrac{\text{adjacent}}{\text{hypotenuse}}\right)} = \frac{\text{opposite}}{\text{adjacent}} = \tan\theta$$

**37. a)** Examples will vary, but all sums should be 1.

**b)** Answers may vary. For example: $(\sin x)^2 + (\cos x)^2 = 1$

**c)** Answers may vary. For example:

$$(\sin x)^2 + \cos x)^2 = \left(\frac{\text{opposite}}{\text{hypotenuse}}\right)^2 + \left(\frac{\text{adjacent}}{\text{hypotenuse}}\right)^2 = \frac{(\text{opposite})^2 + (\text{adjacent})^2}{(\text{hypotenuse})^2} = \frac{(\text{hypotenuse})^2}{(\text{hypotenuse})^2} = 1$$

**38. a)** N8°W **b)** 198 km/h

**39.** D

**40.** 3 $m^2$

**41.** C

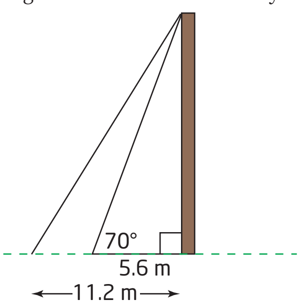
### 7.5 Solve Problems Involving Right Triangles, pages 378–385

**1.** 15.4 m

**2. a)** 16.4 m

**b)** Answers may vary. For example: Use a different trigonometric ratio or the Pythagorean theorem.

**3. a)**




**b)** 19.0 m, 54°

**c)** 16°

**4.** 23 cm

**5.** 22.7 m

**6.** 9.2 m apart

**7. a)** 68°, 53° **b)** 16 m, 10 m

**8. a)** Answers may vary. For example: Use a different trigonometric ratio or the Pythagorean theorem.

**b)** 5.2 m

**9.** Answers may vary. For example: No, because with an angle of 40°, the height of the closest tree is about 25 m tall and Cheryl judges that she can only hit the ball 20 m high. She will hit the tree with the golf ball if she takes this shot.

**10. a)** 49°

**b)** Answers may vary. For example: In order for the golf ball to land near A, Cheryl needs to hit the golf ball 46.1 m. Since Cheryl on average hits the golf ball a distance of 50 m with the sand wedge, this is the club she should use.

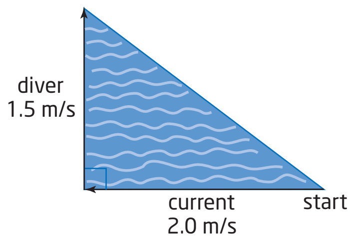
**c)** 63°

**d)** Answers may vary. For example: In order for the golf ball to land near the hole, H, Cheryl needs to hit the golf ball 78.3 m. Since Cheryl on average hits the golf ball a distance of 90 m with the pitching wedge, this is the club she should use.

**11. a)** 34.6 m **b)** 115.1 m **c)** 40.0 m, 101.2 m

**12.** Lucy will escape because the trench is 11.9 m wide but she can leap 12 m, which is just enough!

**13. a)**




**b)** 450 m

**14.** 190 m

**15. a)** Theresa should tell Branko to look for the yellow bottle.

**b)** 84 m

**16.** Answers may vary. For example: Kim lives on the 9th floor and Yuri lives on the 13th floor. Assume every floor has an equal height.

**17.** $20\sqrt{2}$ cm

**18. a)** 2.9 km

**b)** 3.0 km; because the elevation makes the route the hypotenuse of the right triangle with acute angle 15° and adjacent side 2.9 km.

**c)** 0.8 km

**d)** 28°

**19. a)** 13 m **b)** 12 m

**20.** 111 m

**21. a)** 16.6 km **b)** 27°

**22.** 68 m

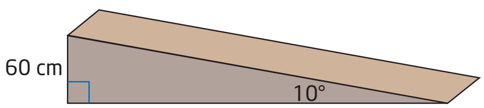
**23.** 42°

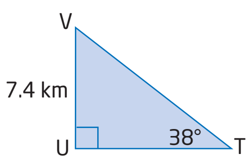
**24.** Watson Lake

**25.** Answers may vary. For example: length AB = $d$. In △ABC, ∠ACB = θ, the hypotenuse is BC, and the opposite side is AB = $d$. Since $\sin\theta = \dfrac{AB}{BC}$, $\sin\theta = \dfrac{d}{BC}$.

26. 1.7 m
27. 5°
28. 705.5 km/h
29. 63°
30. 37 m
31. D
32. $x = 2y + z - 120°$

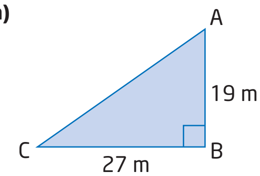
### Chapter 7 Review, pages 386–389

1. **a)** Answers may vary. For example: Similar figures have the same shape, but congruent figures have the same shape and size. For similar figures, all angles are equal and the corresponding sides have equal ratios; for congruent figures, all angles and all sides are equal.
   **b)–e)** Answers will vary.
2. Answers may vary. For example: Yes, because they have the same shape.
3. $\triangle AXP \sim \triangle NTP$ because corresponding pairs of angles are equal: $\angle AXP = \angle NTP$ (alternate angles), $\angle XAP = \angle TNP$ (alternate angles ), and $\angle APX = \angle NPT$ (opposite angles).
4. $\triangle JPW \sim \triangle QBW$; $\frac{JW}{QW} = \frac{PW}{BW} = \frac{JP}{QB} = \frac{1}{2}$
5. **a)** $e = 10$ cm, $f = 6$ cm
   **b)** $q = 4$ cm, $w = 18$ cm
   **c)** $q = 6$ cm, $y = 10$ cm
6. 2.9 m
7. 23.12 m$^2$
8. 9 m
9. **a)** 69° **b)** 42°
10. **a)** 10.5 cm **b)** 14.4 cm
11. 19 m
12. **a)**


   **b)** 340 cm **c)** 346 m
13. **a)** 0, 1, undefined
   **b)** Answers may vary. For example: tan 0° = 0 because the opposite length is 0; tan 45° = 1 because the opposite and adjacent lengths are equal; tan 90° is undefined because the adjacent length is 0 and you cannot divide by 0.
14. 40.5°
15. **a)** $\angle D = 23°$, $\angle E = 67°$
   **b)** $\angle D = 53°$, $\angle E = 37°$
   **c)** $\angle P = 25°$, $\angle Q = 65°$
   **d)** $\angle Q = 35°$, $\angle R = 55°$
16. **a)** 14.8 m **b)** 97.6 m
   **c)** 17.8 mm **d)** 26.4 km
17. $f = 7.0$ m, $\angle F = 49°$, $\angle H = 41°$
18. **a)**


   **b)** $\angle V = 52°$, $v = 9.5$ km, $u = 12.0$ km
19. 11 m
20. 19°; Answers may vary. For example: Assume that her sailboat's speed and the current's speed are constant.
21. **a)** $b = 5.8$ m, $\angle A = 31°$, $\angle C = 59°$
   **b)** $e = 12$ cm, $\angle D = 23°$, $\angle E = 67°$
   **c)** $\angle H = 40°$, $g = 3.1$ m, $h = 2.6$ m
   **d)** $k = 39.2$ mm, $\angle K = 59°$, $\angle M = 31°$
   **e)** $\angle P = 32°$, $p = 30$ cm, $r = 56.6$ cm
   **f)** $\angle T = 35°$, $r = 29.6$ km, $s = 24.3$ km
22. Answers may vary. For example: No, because you need an angle of 9.5° to clear the wires.
23. 68 m
24. Answers may vary. For example: Kathe cannot climb over the fence because the fence is about 2.3 m high and she can only climb 2 m high.
25. 6°
26. 32°
27. 13 m
28. 10°
29. 390 m

### Chapter 7 Practice Test, pages 390–391

1. Figures A and G are congruent. Figures D and B are similar.
2. No. Reasons may vary. For example: No, because the ratios of corresponding sides may not be equal.
3. Yes. Reasons may vary. For example: Yes, because the ratio of corresponding sides are always equal.
4. **a)** 0.5543 **b)** 0.2079
   **c)** 1.0000 **d)** 0.7071
   **e)** 0.7071 **f)** 11.4301
5. **a)** 63° **b)** 55°
   **c)** 69° **d)** 78°
   **e)** 79° **f)** 66°
6. $\angle P = 58°$, $q = 7.3$ cm, $r = 3.9$ cm
7. **a)**


   **b)** $b = 33$ m, $\angle A = 55°$, $\angle C = 35°$
8. Answers may vary. For example: Yes. He should try to jump the creek because it is about 1.8 m wide and he can jump 2 m.
9. **b)** 34° **c)** 3.3 km
10. 558.4 m
11. Branko should give the following advice to Theresa. Since Option A will take 78.8 s and Option B will take 77.6 s, Option B is better.
12. 21 m

## Chapter 8

*Note: Slightly different answers may be obtained if measures are calculated in a different order.*

### Get Ready, pages 394–395

**1. a)** $\sin X = \frac{4.0}{8.1}$, $\cos X = \frac{7.0}{8.1}$, $\tan X = \frac{4.0}{7.0}$

**b)** $\angle X = 30°$, $\angle Z = 60°$

**2. a)** $k = 6.5$ cm; $\sin M = \frac{3.9}{6.5}$, $\cos M = \frac{5.2}{6.5}$,

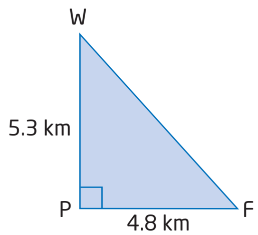
$\tan M = \frac{3.9}{5.2}$

**b)** $\angle M = 37°$, $\angle B = 53°$

**3.** Answers may vary. For example: You could use the Pythagorean theorem or apply the trigonometric ratio for sin T.

**4.** $r = 1.7$ cm, $l = 2.3$ cm, $\angle R = 46°$

**5. a)**




**b)** $p = 7.2$ km, $\angle W = 42°$, $\angle F = 48°$

**6. a)** BY = 17.5 m **b)** 26.6 m

**7.** 86 m

**8. a)** $b = y - mx$ **b)** $d = st$

**c)** $s = \frac{P}{4}$ **d)** $b = P - a - c$

**9. a)** $a = \frac{b(\sin A)}{\sin B}$ **b)** $b^2 = c^2 - a^2$

**c)** $s = \pm\sqrt{\frac{A}{6}}$ **d)** $y = \frac{x(\sin Y)}{\sin X}$

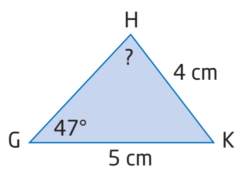
### 8.1 The Sine Law, pages 396–404

**1. a)** $a = 4$ cm **b)** $e = 11$ m

**2. a)** $a = 3.2$ cm **b)** $e = 5.0$ mm

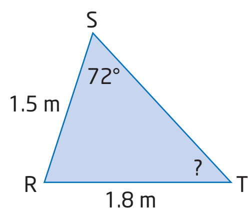
**3. a)** $\angle Y = 44°$ **b)** $\angle C = 56°$

**4. a)**




$\angle H = 66°$

**b)**




$\angle T = 52°$

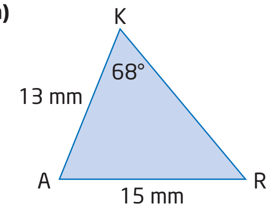
**5. a)** $\angle L = 65°$, $l = 23$ m, $m = 24$ m

**b)** $\angle D = 51°$, $d = 16$ cm, $e = 18$ cm

**6. a)** $\angle D = 55°$, $\angle W = 52°$, $w = 28$ cm

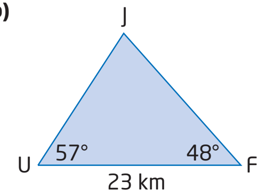
**b)** $\angle Q = 53°$, $\angle P = 66°$, $p = 13$ m

**7. a)**




$\angle R = 53°$, $\angle A = 59°$, $a = 14$ mm

**b)**




$\angle J = 75°$, $f = 18$ km, $u = 20$ km

**8.** Answers will vary.

**9. a)** 1.8 m **b)** 2.4 m

**10.** 7.7 km

**11. a)** 80° **b)** 14 m **c)** 12 m, 2 m

**d)** Answers may vary. For example: Yes. Use the primary trigonometric ratios.

**12.** The valley is 115 m deep.

**13.** 4.7 km

**14.** Answers may vary. For example: Because $a \neq c$, $\angle A \neq \angle C$. Therefore, since $\triangle ABC$ is an isosceles triangle, either $\angle B = \angle A$ or $\angle B = \angle C$. If $\angle B = \angle A$, then $\angle C = 43°$, and the sine law gives $b = 20.5$ cm, which is impossible, because $\triangle ABC$ is isosceles. If $\angle B = \angle C$, then $\angle A = 43°$, and the sine law gives $b = 15$ cm, which is correct, because if $\angle B = \angle C$, then $b = c$.

**15.** 52 m

**16. a)** 1 136 610 km$^2$

**b)** Answers will vary.

**17.** 14.4 m$^2$

**18. a)–c)** Answers will vary.

**19.** No, the sine law does not work if you replace sines with cosines or tangents.

**20. a)** Let $\triangle ABC$ be a right triangle with $\angle B = 90°$ and $b$ the hypotenuse. Then, by the sine law:

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\frac{\sin A}{a} = \frac{\sin 90°}{b} = \frac{\sin C}{c}$$

$$\frac{\sin A}{a} = \frac{1}{b} = \frac{\sin C}{c}$$

So, $\sin A = \frac{a}{b}$ and $\sin C = \frac{c}{b}$.

**b)** Answers may vary. For example: You could, but the sine ratio is faster and already simplified.

**21.** Substitute $s = \dfrac{a + b + c}{2}$ into

$A = \sqrt{s(s - a)(s - b)(s - c)}$.

$$A = \sqrt{\left(\frac{a+b+c}{2}\right)\left(\frac{a+b+c-2a}{2}\right)\left(\frac{a+b+c-2b}{2}\right)\left(\frac{a+b+c-2c}{2}\right)}$$

$$= \sqrt{\frac{(a+b+c)(b+c-a)(a+c-b)(a+b-c)}{16}}$$

$$= \frac{1}{4}\sqrt{(a+b+c)(b+c-a)(a+c-b)(a+b-c)}$$

$$= \frac{1}{4}\sqrt{(a+b+c)(a+b-c)(b+c-a)(a+c-b)}$$

**22.** B

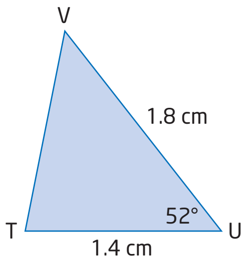
**23.** C

## 8.2 The Cosine Law, pages 405–411

**1. a)** 13 cm **b)** 13 mm

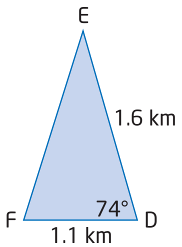
**2. a)** 4.3 m **b)** 1.7 cm **c)** 5.1 mm

**3. a)**




$u = 1.4$ cm

**b)**



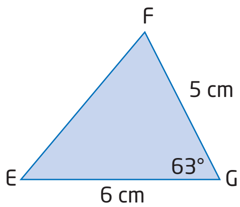

$d = 1.7$ km

**4. a)** $r = 16$ cm, $\angle P = 48°$, $\angle Q = 62°$

**b)** $r = 20$ m, $\angle P = 72°$, $\angle K = 61°$

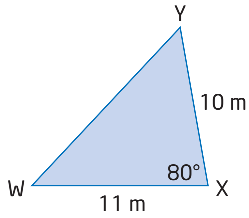
**c)** $a = 10$ m, $\angle C = 58°$, $\angle B = 51°$

**5. a)**




$g = 6$ cm, $\angle F = 63°$, $\angle E = 54°$

**b)**




$x = 14$ m, $\angle W = 49°$, $\angle Y = 51°$

**6.** Answers will vary.

**7.** 56 m

**8. a)** 2.6 km **b)** 45°, 65°

**9.** 39.8 cm

**10. a)** 7.7 nautical miles

**b)** 15.3 nautical miles

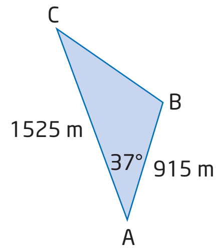
**c)** 14.7 nautical miles, 29.5 nautical miles

**11. a)** 9.8 cm

**b)** $\angle B = 84.5°$, $\angle C = 34.0°$

**12. a)–c)** Answers will vary.

**13. a)** Diagrams may vary.




**b)** 966 m

**14.** 12 km

**15.** Let △ABC be a right triangle with $\angle C = 90°$ and $c$ the hypotenuse. Then, by the cosine law,

$$\begin{aligned} c^2 &= a^2 + b^2 - 2ab(\cos C) \\ &= a^2 + b^2 - 2ab(\cos 90°) \\ &= a^2 + b^2 - 2ab(0) \\ &= a^2 + b^2 \end{aligned}$$

**17.** Answers will vary.

**18. a)** 15.8 cm **b)** 37.75°

**19.** Answers may vary. For example: 53 cm, assuming the there is no slack in the drive belt.

**20.** D

**21.** Answers may vary.

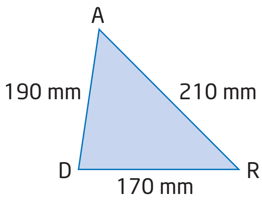
$$\begin{aligned} &(\sin A)^2 + (\cos A)^2 \\ &= \left(\frac{\text{opposite}}{\text{hypotenuse}}\right)^2 + \left(\frac{\text{adjacent}}{\text{hypotenuse}}\right)^2 \\ &= \frac{(\text{opposite})^2 + (\text{adjacent})^2}{(\text{hypotenuse})^2} \\ &= \frac{(\text{hypotenuse})^2}{(\text{hypotenuse})^2} \\ &= 1 \end{aligned}$$

### 8.3 Find Angles Using the Cosine Law, pages 412–419

**1. a)** 49° **b)** 61° **c)** 50°

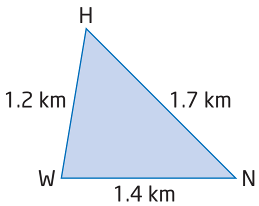
**2. a)** 51° **b)** 66° **c)** 49°

**3. a)**




$\angle D = 71°$

**b)**




$\angle W = 81°$

**4. a)** $\angle J = 55.5°$, $\angle V = 81.4°$, $\angle M = 43.1°$

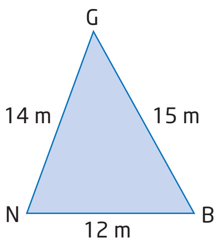
**b)** Solve for $\angle J$ using the cosine law. Solve for $\angle V$ using the sine law. Then, solve for $\angle M$ using the fact that the sum of the interior angles in a triangle is 180°.

**c)** The answers are the same. Explanations may vary. For example: The calculations in my method are easier to complete.

**5. a)** $\angle V = 78.5°$, $\angle T = 57.1°$, $\angle U = 44.4°$

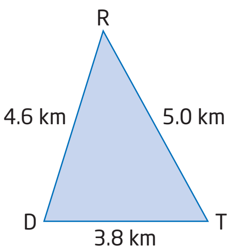
**b)** $\angle M = 70.8°$, $\angle P = 59.0°$, $\angle Y = 50.2°$

**6. a)**




$\angle N = 70.0°$, $\angle B = 61.3°$, $\angle G = 48.7°$

**b)**




$\angle D = 72.3°$, $\angle T = 61.2°$, $\angle R = 46.4°$

**7.** Answers will vary.

**8. a)** 78°, 51°, 51° **b)** 14 $m^2$

**9.** 31°

**10. a)** 82° **b)** 43° **c)** 55°

**11.** 69.6°, 110.4°, 69.6°, 110.4°

**12.** Answers will vary.

**13.** 51.3°, 51.3°, 77.4°. Answers may vary. For example: No, there is only one possible triangle for three given sides.

**15. a)**
$$\cos A = \frac{a^2 - b^2 - b^2}{-2b(b)}$$
$$= \frac{a^2 - 2b^2}{-2b^2}$$
$$= \frac{a^2}{-2b^2} - \frac{2b^2}{-2b^2}$$
$$= \frac{a^2}{-2b^2} + 1$$
$$= 1 - \frac{a^2}{2b^2}$$

**b)** $\angle A = 30.9°$, $\angle B = \angle C = 74.55°$

**16.** Answers may vary. For example: For an equilateral triangle, $a = b = c$.
Substitute into the cosine law.
$$\cos A = \frac{a^2 - b^2 - c^2}{-2bc}$$
$$\cos 60° = \frac{a^2 - a^2 - a^2}{-2a(a)}$$
$$\cos 60° = \frac{-a^2}{-2a^2}$$
$$\cos 60° = \frac{1}{2}$$

### 8.4 Solve Problems Using Trigonometry, pages 424–429

**1. a)** cosine law **b)** sine law
**c)** primary trigonometric ratios
**d)** cosine law

**2. a)** $x = 5.6$ m **b)** Answers will vary.

**3. a)** $x = 4.4$ cm **b)** $x = 4.4$ cm

**4.** 1.6 km

**5. a)** Diagrams may vary. **b)** 239 360 000 km
**c)** Answers may vary. For example: No, because the angle between Earth, the Sun, and Mars is not always the same.

**6. a)** 47 km **b)** $\angle R = 65°$, $\angle D = 74°$, $\angle H = 41°$

**7.** 9.6 m

**8.** Yes, because it would take Biff 12 s and Rocco 12.9 s to reach the eucalyptus. Assumptions may vary.

**9.** 79.8 m. Answers may vary. For example: assume that the bridge is symmetric. Find the unknown angles and sides using triangle laws, the sine law, and the cosine law.

**10.** 6.4 km. Answers may vary. For example: Assume that the paths are straight.

**11.** 8.2 cm

**12. a)** The distance is 146 677 195.5 km, which is close to 149 600 000 km.
**b)** Answers may vary. For example: Noon, when the Sun appears to be directly overhead.

**13. a)** S51°E **b)** 108 km/h

**14. a)** Javier and Raquel live about 19.7 m vertically apart.
**b)** Answers may vary. For example: I assumed that the balconies were equally spaced. Then, I used the tangent ratio with two right triangles formed by drawing a horizontal line between buildings through point H.

**15. a)** The longest rod fits from the bottom front left corner to the top back right corner. The length of the rod, $l$, is the hypotenuse of the right triangle, whose legs are the height of the prism and the diagonal of the base of the prism.

$$\begin{aligned} l &= \sqrt{(w^2 + w^2) + (2w)^2} \\ &= \sqrt{6w^2} \\ &= \sqrt{6}w \end{aligned}$$

**b)** 35.3° and 65.9°

**16.** 117 km, S78°E

**17.** Answers will vary.

## Chapter 8 Review, pages 430–431

**1.** 10 cm

**2.** 41°

**3. a)** $\angle T = 42°$, $\angle K = 87°$, $k = 36$ km
**b)** $\angle C = 53°$, $c = 22$ mm, $n = 20$ mm

**4. a)** 37 cm **b)** 61° and 37°

**5.** 20 m

**6. a)** $u = 54$ mm, $\angle D = 59°$, $\angle P = 82°$
**b)** $w = 16$ km, $\angle E = 45°$, $\angle Q = 58°$

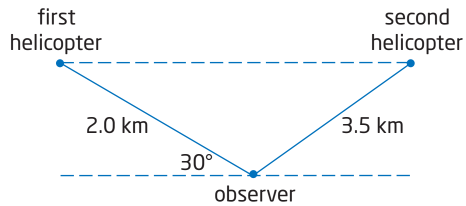
**7. a)** 33 km **b)** 53°

**8. a)** 39°

**9. a)** $\angle S = 72.7°$, $\angle F = 54.9°$, $\angle V = 52.4°$
**b)** $\angle B = 79.6°$, $\angle S = 62.9°$, $\angle Z = 37.5°$

**10.** angle to water tower 37°, angle to monument 47°

**11. a)** Diagrams may vary.




**b)** 5.1 km **c)** 1 km

**12.** 70 m

## Chapter 8 Practice Test, pages 432–433

**1.** 18 cm

**2.** 2.5 m

**3.** 47°

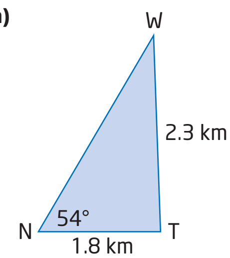
**4.** 58°

**5. a)** 3.2 m **b)** 60° and 40°

**6.** 33.2°

**7.** $x = 8.7$ m, $\angle Y = 50°$, $\angle Z = 62°$

**8. a)**




**b)** $\angle W = 39°$, $\angle T = 87°$, $t = 2.8$ km

**9.** 47.5 cm; assume the crest is symmetric.

**10.** 75 m

**11.** 40 km

**12.** 361 m; S74°W

**13. a)** blue jay tree 36.1 m, cardinal tree 25.3 m
**b)** 41.4 m

**14.** 40 min

**15.** plane's altitude 10 km, jet's altitude 13 km

## Chapters 7 and 8 Review, pages 434–435

**1.** $\angle B = \angle E = 90°$. $\angle ACB = \angle DCE$ (opposite angles). Then, $\angle A = \angle D$ (angle sum of a triangle is 180°). Therefore, $\triangle ABC \sim \triangle DEC$ because corresponding pairs of angles are equal.

**2.** $h = 14$ cm, $q = 14$ cm

**3. a)** $\angle E = 53°$, $\angle C = 37°$ **b)** $\angle X = 54°$, $\angle Y = 36°$
**c)** $\angle U = 33°$, $\angle T = 57°$ **d)** $\angle M = 35°$, $\angle N = 55°$

**4. a)** 6.1 cm **b)** 29.9 m
**c)** 5.4 km **d)** 99.0 cm

**5. a)** $b = 11.9$ cm, $\angle A = 51°$, $\angle C = 39°$
**b)** $\angle H = 31°$, $f = 9.7$ m, $g = 11.3$ m

**6.** 4.2 m

**7. a)** 20 m **b)** 59 m

**8.** 9 cm

**9.** 3.9 m

**10.** $\angle P = 51°$

**11.** $\angle E = 70°$

**12. a)** $\angle B = 65°$, $\angle A = 71°$, $a = 18$ mm
**b)** $r = 26$ m, $\angle S = 75°$, $\angle T = 51°$
**c)** $x = 30$ cm, $\angle Y = 67°$, $y = 28$ cm
**d)** $e = 36$ km, $\angle F = 62°$, $\angle G = 34°$

**13. a)** $\angle C = 75.4°$, $\angle B = 61.3°$, $\angle A = 43.3°$
**b)** $\angle V = 70.1°$, $\angle U = 59.1°$, $\angle T = 50.8°$

**14.** 41 km

**15.** 1171 m

**16.** 3149 m

## Course Review, pages 438–447

**1. a)** Let $l$ represent the length and $w$ represent the width. $2l + 2w = 40$.
**b)** If $n$ represents one number and $q$ represents the other number, then $\frac{n+q}{2} = 15$.
**c)** If $q$ represents the number of quarters and $l$ represents the number of loonies, then $0.25q + l = 37$.
**d)** If $a$ represents the number of adult tickets sold and $s$ represents the number of student tickets sold, then $20a + 12s = 9250$.

**2. a)** $(3, -1)$ **b)** $(-2, -5)$ **c)** $(2, 2)$

**3. a)** $x = 2$, $y = 1$ **b)** $x = 1$, $y = 3$ **c)** $x = 1$, $y = 1$

**4. a)** $x = 17$, $y = 38$ **b)** $a = 4$, $b = -3$
**c)** $k = 1.5$, $h = 2$ **d)** $a = 3$, $b = 5$

**5.** The lines have the same slope, but a different $y$-intercept. So, the lines are parallel and they have no point in common.

**6. a)** $(6.7, 1.7)$ **b)** $(-4.4, -2.3)$ **c)** $(-0.1, -0.9)$

**7.** $a = 32$, $b = 20$

**8.** boat 16 km/h, current 4 km/h

**9.** 25 mL of 60% hydrochloric acid and 100 mL of 30% hydrochloric acid

**10.** $x = 5$, $y = 4$

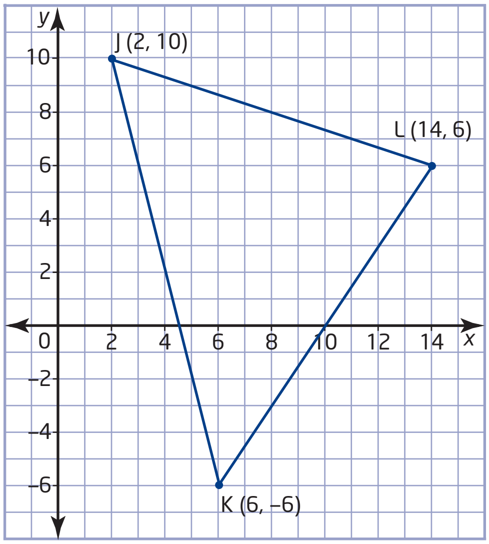
**11.** for AB, midpoint is (2, 3), length is $\sqrt{80}$; for CD, midpoint is (−5, 0), length is $\sqrt{80}$; for EF, midpoint is $\left(2, -\frac{3}{2}\right)$, length is $\sqrt{65}$

**12.** **a)** $y = 6.5x - 2.5$ **b)** $y = 0.2x - 0.4$ **c)** $y = \frac{1}{4}x - \frac{1}{2}$

**13.** **a)** Fire station B is closer.
**b)** Answers will vary.

**14.** DEFG is a kite. Adjacent sides are equal in length: $DE = DG = \sqrt{80}$, and $EF = FG = \sqrt{200}$.

**15.** **a)**




**b)** M(4, 2), N(8, 8)
**c)** The length of $MN = 2\sqrt{13}$ and length of $KL = 4\sqrt{13}$, so MN is half the length of KL.
**d)** slope MN = slope KL = $\frac{3}{2}$

**16.** No. The equation of the right bisector is $y = \frac{3}{2}x + \frac{3}{2}$, but the point (−3, −2) does not satisfy this equation.

**17.** **a)** Slope AB = slope CD = 1, so AB is parallel to BC. Slope AD = $-\frac{2}{7}$ and slope BC = $\frac{1}{2}$, so ABCD is not a parallelogram. It is a trapezoid.
**b)** Answers will vary.

**18.** **a)** The shortest pipe will be the perpendicular from H to WM. The equation of WM is $y = 4x - 6$. The equation of the new pipe is $y = -\frac{1}{4}x + 28$. These two lines intersect at (8, 26).
**b)** $2\sqrt{17}$ m, or approximately 8.25 m.

**19.** **a)** $x^2 + y^2 = 49$ **b)** $x^2 + y^2 = 61$ **c)** $x^2 + y^2 = 67$

**20.** The diameter is 16 units; the area is approximately 201 square units.

**21.** 42 cm

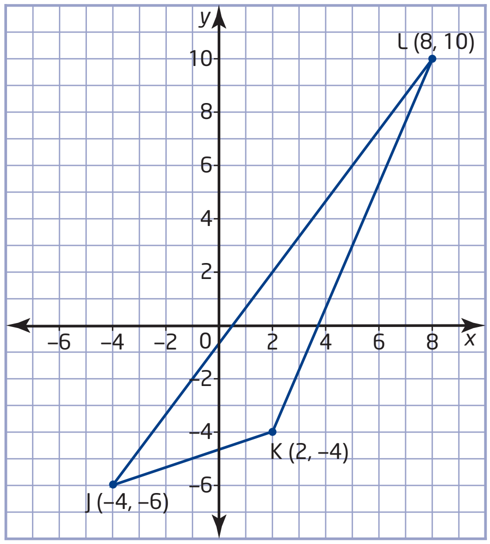
**22.** **a)** The centroid is the point where the three medians of a triangle intersect.
**b)** Determine the equation of two of the medians of the triangle and then find the point of intersection of these two lines.
**c)** Answers will vary.

**23.** **a)** Answers will vary.
**b)** Answers will vary.

**24.** $AC = BC = \sqrt{160}$, so △ABC is isosceles.

**25.** **a)** Slope DE = $-\frac{5}{3}$ and slope EF = $\frac{3}{5}$, so DE is perpendicular to EF and △DEF is a right triangle.
**b)** Show that the side lengths satisfy the Pythagorean theorem.

**26.** **a)**




**b)** Let X, Y, and Z be the midpoints of JL, LK, and KJ. Then the coordinates of these midpoints are X(2, 2), Y(5, 3) and Z(−1, −5). Comparing lengths: $XY = \sqrt{10}$, $JK = 2\sqrt{10}$, $YZ = 10$, $JL = 20$, $XZ = \sqrt{58}$, and $KL = 2\sqrt{58}$. Corresponding sides are in proportion, 1:2, so the triangle joining the midpoints of the sides of △JKL is similar to △JKL.

**27.** **a)** The equation of the right bisector of JK is $y = \frac{-4}{3}x + \frac{35}{3}$. The equation of the right bisector of JL is $y = 2x - 5$. The equation of the right bisector of KL is $y = -\frac{1}{2}x + \frac{15}{2}$.
**b)** (5, 5)
**c)** The distance from the centroid to each vertex is 5 units.

**28.** **a)** squares, rectangles
**b)** squares, rhombii, parallelograms
**c)** squares, rhombii, kites

**29.** **a)** Answers will vary.

**30. a)** $AB = CD = \sqrt{41}$; $BC = AD = \sqrt{52}$

Slope $AB$ = slope $CD = \frac{5}{4}$ and

slope $AD$ = slope $BC = -\frac{2}{3}$, so opposite sides are parallel. Therefore, ABCD is a parallelogram.

**b)** The diagonals intersect at $\left(3, 2\frac{1}{2}\right)$ and the distance from this point to each vertex is $\frac{\sqrt{85}}{2}$. Therefore, the diagonals bisect each other.

**31.** parallelogram

**32. a)** $PC = QC = RC = \sqrt{13}$

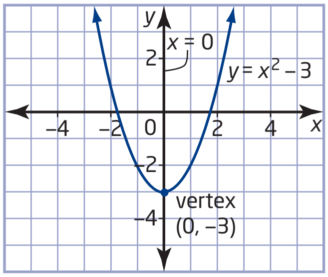
**b)** An equation for the right bisector of chord PQ is $y = -\frac{2}{3}x + \frac{14}{3}$. The centre (4, 2) satisfies this equation.

**33.** Answers will vary.

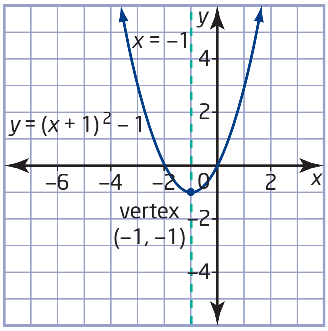
**34. a)** neither **b)** linear **c)** linear

**35. a)** 2.1 m **b)** 4.43 m **c)** 3.05 m

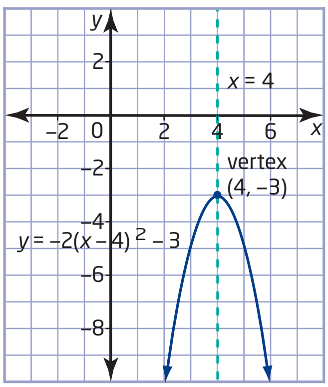
**36. a)**



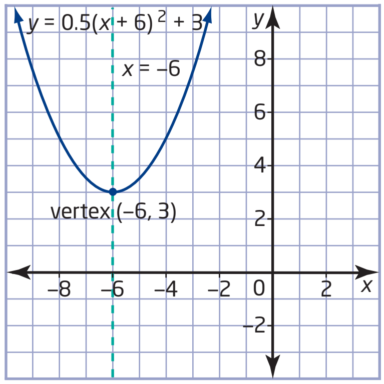

**b)**



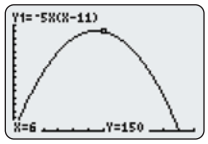

**c)**




**d)**




**37. a)**




**b)** 151 m **c)** 5.5 s

**d)** The lava will be ejected away from the crater and so it will probably fall on land that is below the crater. The length of time in the air will probably be more than 11 s.

**38. a)** $y = -2x^2 + 3$ **b)** $y = x^2 + 2x - 15$

**39.** $-11$

**40. a)** 1 **b)** $\frac{1}{3}$ **c)** $-\frac{1}{32}$

**d)** $\frac{25}{4}$ **e)** 1 **f)** $\frac{3}{4}$

**41. a)** 1024 s **b)** $\frac{1}{32}$ s

**42. a)** $8x + 18$ **b)** $4a + 28$ **c)** $2 - 8k$

**d)** $8t^2 - 3t$ **e)** $-3 + 9p$ **f)** $y^3 - 7y$

**43. a)** $10x^2 + 10x - 10$ **b)** 290 cm$^2$

**44. a)** $x^2 + 8x + 16$ **b)** $y^2 - 16$

**c)** $a^2 - 10a + 25$ **d)** $9t^2 - 1$

**e)** $25a^2 - 9b^2$ **f)** $18m^2 + 12m + 2$

**45. a)** $2m^2 - 8m + 7$ **b)** $30t^2 + 12t + 1$

**c)** $-9x^2 + 18xy - 11y^2$ **d)** $9y^2 + 4$

**e)** $18m^2 + 9n^2$ **f)** $68t^2 - 100tz + 98z^2$

**46. a)** $5(k - 7)$ **b)** $4h(h - 5)$

**c)** $2xy(1 - 4y)$ **d)** $(x - 5)(x + 5)$

**e)** $(1 - 7m)(1 + 7m)$ **f)** $4(a - 2b)(a + 2b)$

**47. a)** length $n - 2$, width $n - 3$

**b)** perimeter 22 cm, area 30 cm$^2$

**48. a)** $(x + 3)(x - 4)$ **b)** $(y + 6)(y - 3)$

**c)** $(m + 3)(m + 8)$ **d)** $(t - 3)(t - 5)$

**e)** not possible **f)** $(n - 5)(n - 8)$

**g)** $(w + 5)(w - 6)$ **h)** $(7 - m)(2 + m)$

**49. a)** $(x + 5)^2$ **b)** $(y - 6)^2$ **c)** not possible

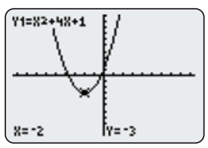
**d)** $(2x + 3)^2$ **e)** $(5r - 2s)^2$ **f)** $5(x - 2y)^2$

**50.** Answers will vary.

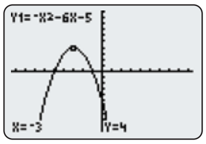
**51. a)** 8, $-8$ **b)** 9 **c)** 25

**52.** $m = \pm 5$ and $n = \pm 2$, or $m = \pm 11$ and $n = \pm 10$

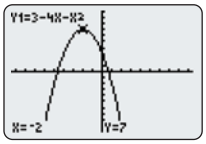
**53. a)**




$y = (x + 2)^2 - 3$, vertex $(-2, -3)$, axis of symmetry $x = -2$

**b)** 

$y = -(x + 3)^2 + 4$, vertex $(-3, 4)$, axis of symmetry $x = -3$

**c)** 

$y = -(x + 2)^2 + 7$, vertex $(-2, 7)$, axis of symmetry $x = -2$

**54.** **a)** $(-1.5, 0.5)$ **b)** $(0.3, 1.3)$ **c)** $(-0.3, -3.7)$

**55.** **a)** $-3, 1$ **b)** $-5, -1$ **c)** 2 **d)** 1.5

**56.** **a)** $4, -7$ **b)** $-5, -2$ **c)** $-9, 1.5$ **d)** $1, \frac{4}{3}$

**57.** Answers will vary.

**58.** **a)** $\frac{25}{8}$ **b)** 6 or $-6$ **c)** 4

**59.** 9 cm by 4 cm

**60.** **a)** $\frac{1 \pm \sqrt{17}}{2}$ **b)** $\frac{1 \pm \sqrt{15}}{7}$ **c)** $\frac{-4 \pm \sqrt{22}}{2}$ **d)** $\frac{-1 \pm \sqrt{6}}{2}$ **e)** $\frac{2 \pm \sqrt{7}}{3}$

**61.** **a)** 110; \$160 **b)** \$120; 130

**62.** 12 cm, 16 cm

**63.** 2.5 m

**64.** $\triangle ADE \sim \triangle ACB$; $\angle A$ is common; $\angle ADC = \angle ACB$ (corresponding angles).

**65.** 21.5 m

**66.** **a)** 33° **b)** 60°

**67.** 4.6°

**68.** **a)** 7.6 m **b)** 5.9 cm

**69.** **a)** $\angle A = 57°$, $a = 47$ cm, $b = 30$ cm
**b)** $\angle F = 49°$, $d = 80$ m, $e = 52$ m
**c)** $\angle T = 42°$, $\angle U = 48°$, $u = 11$ m
**d)** $\angle P = 32°$, $\angle R = 58°$, $q = 15$ cm

**70.** XY = 3.3 cm, $\angle Y = 43°$, $\angle Z = 47°$

**71.** 60°

**72.** **a)** 16.6 km **b)** 26.9°

**73.** 60.0 m

**74.** 30 cm

**75.** 57°

**76.** 79.5 cm

**77.** **a)** $\angle R = 43.4°$, $\angle Q = 85.6°$, $q = 55.2$ cm
**b)** $\angle J = 73°$, $k = 20.7$ cm, $l = 11.4$ cm

**78.** 4.7 cm, 6.0 cm

**79.** 13.9 m

**80.** $\angle K = 57.3°$, $\angle L = 48.7°$, $\angle M = 74.0°$

**81.** 104 $m^2$

**82.** 40.8 cm

**83.** **a)** 93.6 m **b)** 97.9 m

**84.** 4.0 km

**85.** **a)** $\angle F = 69°$, $f = 8.8$ cm, $e = 7.5$ cm
**b)** $\angle T = 46°$, $s = 7.3$ m, $\angle S = 61°$
**c)** $a = 6.9$ cm, $\angle B = 42°$, $\angle C = 70°$
**d)** $\angle W = 51°$, $\angle X = 46°$, $\angle Y = 83°$

**86.** 68°

## Challenge Problems Appendix, pages 448–457

**1.** Answers will vary.

**2.** Answers will vary.

**3.** **a)** (5, 4) **b)** (4, 5) **c)** $(-1, -5)$ **d)** $\left(\frac{1}{2}, -\frac{1}{2}\right)$

**4.** 20 $cm^2$

**5.** $x = 4$, $y = 6$

**6.** Answers may vary. For example: $2x + 3y = -3$, $x - 2y = 16$

**7.** 31, 49

**8.** **a)** 1.8 h **b)** 135 km

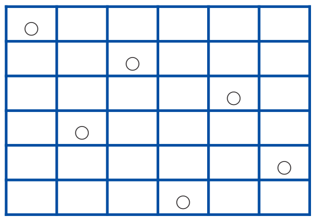
**9.** **a)** 24, 23, 30 **b)** 42, 68, 110 **c)** 37, 50, 65

**10.** $b = 10$, $n = 7$

**11.** $(-4, 0)$, $(4, 0)$, $(0,6)$

**12.** **a)** slope of PS = slope of QR = $\frac{1}{2}$; slope of PQ = $-3$, slope of SR = $-\frac{1}{5}$
**b)** The midpoint of PQ is A$(-2, -2)$, and the midpoint of SR is B(6, 2); the slope of AB = $\frac{1}{2}$, which is the same as the slope of the bases PS and QR.
**c)** PS = $2\sqrt{5}$, QR = $6\sqrt{5}$, AB = $4\sqrt{5}$, so PS + QR = 2AB

**13.** Answers may vary.



**14.** 60 square units

**15.** 32 square units

**16.** Rohan

**17.** 30 cm by 20 cm

**18.** **a)** linear: $y = 3x - 2$
**b)** quadratic: $y = -3x^2 + 4$
**c)** quadratic: $y = x^2 + 6x + 5$
**d)** neither

**19.** **a)** 0.8 m **b)** 8 m **c)** 1.25 m

**20.** **a)** $a^2 + b^2 + c^2 + 2ab + 2ac + 2bc$
**b)** $4x^2 + 9y^2 + 1 + 12xy + 4x + 6y$

**21.** **a)** $(x^2 + 1)^2$ **b)** $(x^2 + 3)(x^2 - 2)$ **c)** $(x^2 - 5)(x^2 + 2)$ **d)** $(x^2 + 9y)(x^2 + y)$

**22.** **a)** 8 m **b)** 16

**23.** 18, 20, 24

**24.** **a)** $(2x^2 + 1)(x^2 + 1)$ **b)** $(2x^2 - 1)(x^2 + 3)$ **c)** $(3x^2 - 4)(x^2 + 1)$ **d)** $(2x^2 - 3)(3x^2 - 2)$ **e)** $(2x^2 + y)(x^2 + 2y)$ **f)** $(3x^2 - y)(x^2 + 4y)$

**25.** 20 units, 12 units, 4 units

**26.** **a)** $y = m^2 - 2m + 2$ **b)** $y = 8k^2 + 8k - 1$ **c)** $y = 9t^2 + 6t - 4$ **d)** $y = 12w^2 - 32w + 25$

**27.** 4 cm by 8 cm by 18 cm

**28.** **b)** month 23
**c)** $P = 100(m - 11)^2 - 12\,100$

29. a) A closed dot is used to show the location of an ordered pair on a graph; an open dot is used to show that an ordered pair is omitted from the graph.
b) more than 3 h but not more than 4 h
c) $200
30. 6 cm by 4 cm
31. a) $y = x^2 + 2$ b) $y = -x^2 - 1$
c) $y = 2x^2 - 3$ d) $y = -\frac{1}{2}x^2 + 4$
32. a) $y = (x + 4)^2 - 5$ b) $y = -(x - 1)^2 + 6$
c) $y = 3(x + 2)^2 + 3$
33. a) $a = 2, k = 4$ b) $a = -1, k = -4$
c) $a = -2, k = 5$
34. a) $k = -8$ b) $k > -8$ c) $k < -8$
35. a) $\frac{1}{2^5}$ b) $\frac{1}{5^2}$ c) $3^4$
36. a) $\frac{x^2}{3}$ b) $\frac{1}{(3x)^3}$ c) $\frac{1}{8y^3}$
37. 20 routes
38. a) $b = 0$ b) $x = 0$ always, $x = -b$
39. a) $x^2 - x - 6 = 0$
b) Yes—any constant multiple of $x^2 - x - 6 = 0$.
40. a) 10 b) $-\frac{1}{3}$
41. 31, 32
42. 14 $m^2$
43. 3.2 cm
44. a) no real roots
b) two real, equal roots
c) two real, distinct roots
d) two real, distinct, irrational roots
45. 1:2
46. 60 $cm^2$
47. $x = 3.7$ cm, $\angle A = 38°$
48. 31 cm
49. $a = 6.1, b = 4.1, c = 5.8, \angle A = 73.1°, \angle B = 40.4°, \angle C = 66.5°$
50. These side lengths cannot form a triangle, since $3 + 4 < 8$.
51. $a = 2, b = 3, c = 4$
52. 6
53. a) 1600 $m^2$ b) 7°
54. base 6 cm, height 8 cm
55. 192.5 $cm^2$
56. 12
57. 60
58. $A = 3, B = 2, C = 4$, or $A = 1, B = 8, C = 3$, or $A = -3, B = -4, C = 2$

# Prerequisite Skills Appendix, pages 458–475

## Adding Polynomials, page 458

1. a) $7x + 5y + 12$ b) $9x - 6y - 12$ c) $3x^2 + 2x + 4$
d) $5a^2 + 3a + 1$ e) $-y^2 - 1$ f) $-2a - b - 3$

## Angle Properties, page 458

1. a) $x = 41°$
b) $a = 115°, b = 65°, c = 65°, d = 115°, e = 65°, f = 115°, g = 65°$
c) $w = 74°, x = 70°, y = 36°, z = 70°$
d) $w = 79°, x = 101°, y = 101°$

## Common Factoring, page 459

1. a) $3x + 4y$ b) $2x - 5$ c) $2c + 5$
d) $2a - 3$ e) $ab + 2c$ f) $x - 2$
2. a) $5(y + 3)$ b) $8(3x - 2)$
c) $2a(2b + 3)$ d) $3x(x - 6)$
e) $2x(x^2 + 2x - 3)$ f) $3x(2x^2 - x + 3)$
g) $4ab(2b + 1 + 3a)$ h) $10(y^3 - 1)$

## Congruent Triangles, page 460

1. a) $\angle P = \angle S, \angle Q = \angle T, \angle R = \angle U$, PQ = ST, PR = SU, QR = TU
b) $\angle A = \angle K, \angle B = \angle L, \angle C = \angle M$, AB = KL, AC = KM, BC = LM

## Evaluating Expressions, page 460

1. a) 13 b) 11 c) 12 d) 6
e) 18 f) 11 g) 30 h) −2
i) −3 j) −21 k) 4 l) 0
2. a) 2 b) 1 c) −25 d) 12
e) −10 f) −11 g) 12 h) 0
i) 4 j) 216 k) −36 l) −41
3. a) 6, 5, 4, 3, 2 b) 1, −1, −3, −5, −7
c) 3, 4, 5, 6, 7 d) 5, 2, 1 2, 5
e) 8, 3, 0 −1, 0 f) 4, 3, 4, 7, 12

## Evaluating Radicals, page 462

1. a) 2 b) 5 c) 0.9 d) 1.1
e) 0.3 f) 0.1 g) 15 h) 1.3
2. a) 6.6 b) 11.4 c) 58.5 d) 4.5
e) 9.5 f) 27.3 g) 256.5 h) 0.8

## Expanding Expressions, page 462

1. a) $2x + 6$ b) $3x + 3y - 21$
c) $5a - 5b + 5c$ d) $-10a + 8$
e) $-2x + y$ f) $x^2 + 6x$
g) $6x^2 + 14x$ h) $x^3 - x^2 + 5x$
i) $-3a^3 - 6a^2 + 3a$

## Exponent Rules, page 462

1. a) $2^7$ b) $3^{10}$ c) $4^7$ d) $5^6$
e) $2^2$ f) $3^3$ g) $4^5$ h) $2^6$
i) $3^{12}$ j) $y^{11}$ k) $z^6$ l) $y$
m) $z^6$ n) $x^{15}$ o) $y^{16}$ p) $6x^7$
q) $6x^7$ q) $8y^7$ r) $5m^4$ s) $9y^6$
t) $-8x^9$

## First Differences, page 463

1. a) linear b) linear c) non-linear d) linear

### Graphing Equations, page 464

1. a) line through (0, 4) and (4, 0)
   b) line through (0, −2) and (2, 0)
   c) line through (0, 2) and (−2, 0)
   d) line through (0, 1) and (1, 3)
2. a) $x$-intercept 3, $y$-intercept 3
   b) $x$-intercept 4, $y$-intercept −4
   c) $x$-intercept 2, $y$-intercept 8
   d) $x$-intercept 5, $y$-intercept −2
3. a) slope 1, $y$-intercept 3
   b) slope −1, $y$-intercept −4
   c) slope 2, $y$-intercept 3
   d) slope 3, $y$-intercept −1
4. a) (6, 2) b) (2, 5) c) (4, −2) d) (−1, 4)

### Greatest Common Factors, page 465

1. a) $2x$ b) $4y$ c) $5z$ d) $10a$
   e) $2x$ f) $7ab$ g) $6x^2$ h) $abc$
2. a) $2a$ b) $3y$ c) $4x^2$ d) $3mn$
   e) $5rt^2$ f) 9

### Lengths of Line Segments, page 466

1. a) 6 b) 4 c) 6 d) 8
   e) 7 f) 13 g) 4 h) 12
   i) 6 j) 7 k) 14 l) 6

### Like Terms, page 466

1. a) $6x$ b) $5y - 14$
   c) $3x - y - 7$ d) $4a - 5b + 4c$
   e) $-2x^2 - 9x - 3$ f) $-t^2 + t - 4$
   g) $4x + 9y - 8$ h) $-y^2 - 18y + 3$
   i) $-2t^2 - 10t + 15$

### Number Skills, page 467

1. a) 33 b) 195 c) 108 d) $3\frac{4}{15}$
   e) $-\frac{1}{4}$ f) $1\frac{1}{2}$ g) $-\frac{1}{5}$ h) 0.5
   i) 64.4
2. a) $\frac{1}{2}, \frac{7}{12}, \frac{3}{5}, \frac{5}{8}, \frac{2}{3}$ b) $3\frac{5}{9}, 3\frac{3}{4}, 3\frac{6}{7}, 3\frac{7}{8}$
3. a) $\sqrt{9 + 16} = 5, \sqrt{9} + \sqrt{16} = 7$
   b) $(x + y)^2 = x^2 + 2xy + y^2$
   c) $\frac{2}{3} + \frac{5}{6} = \frac{3}{2}$

### Percents, page 468

1. a) 75%, 0.75 b) 50%, 0.5
   c) 840%, 8.4 d) $\frac{17}{50}$, 0.34
   e) $\frac{3}{10\,000}$, 0.0003 f) $\frac{7}{125}$, 0.056
   g) $\frac{9}{20}$, 45% h) $\frac{3}{100}$, 3%
   i) $2\frac{17}{25}$, 269%

### Polynomials, page 468

1. a) 1 b) 3 c) 2
   d) 3 e) 4 f) 5

### Pythagorean Theorem, page 469

1. a) 5.8 b) 7.2 c) 4.9
   d) 6.7 e) 7.4 f) 8.1

### Simplifying Expressions, page 469

1. a) $7x + 14$ b) $9a - 21$ c) $2x - 12$
   d) $-5y + 21$ e) $5t - 4$ f) $7y - 30$
   g) $-6z - 8$ h) $17 - 2w$ i) $8x - 18$
2. a) $5x + 7y$ b) $5r + s$ c) $-p + 6q$
   d) $20x - 9y$ e) $5a + 21b$ f) $-c + 19d$
   g) $2a - 3b + 5c$ h) $10x + 3y - 6z - 5$
   i) $14x + 17y - 4z$

### Slope, page 470

1. a) 3 b) $\frac{1}{2}$ c) 2 d) 2
   e) −2 f) $\frac{1}{5}$ g) 0 h) −2
   i) $\frac{3}{2}$
2. a) $3, -\frac{1}{3}$ b) $-2, \frac{1}{2}$ c) −1, 1 d) $\frac{1}{4}, -4$
   e) $-\frac{2}{3}, \frac{3}{2}$ f) $\frac{4}{5}, -\frac{5}{4}$

### Solving Equations, page 471

1. a) 3 b) 6 c) −3 d) 4
   e) −7 f) −2 g) 1 h) −8
   i) −4
2. a) 1 b) 5 c) 4 d) −4
   e) −9 f) 18 g) 1 h) 2
   i) −6
3. a) 9 b) 1 c) 4 d) 7
   e) 5 f) −2 g) −2 h) 3
   i) 7

### Solving Proportions, page 473

1. a) $\frac{12}{5}$ b) $\frac{12}{5}$ c) $\frac{14}{3}$ d) $\frac{8}{3}$
   e) $\frac{10}{3}$ f) $\frac{28}{3}$ g) $\frac{8}{3}$ h) $\frac{16}{5}$
2. a) 15.3 b) 0.45 c) 13.76 d) 1.3
   e) 0.27 f) 1.25 g) 6.98 g) 1.04

### Subtracting Polynomials, page 474

1. a) $2x + 4y + 3$ b) $3x - 2y - 1$
   c) $-x^2 - 8x - 9$ d) $3a^2 + 6a + 11$
   e) $-7a + 6b + 7$ f) $7y^2 - 4y - 2$