6. Graph each parabola. State the coordinates of the vertex. Find any intercepts.

a) $y = x^2 - 9$ **b)** $y = x^2 + 1$
c) $y = -x^2 + 4$ **d)** $y = 2x^2 - 8$
e) $y = 16 + x^2$ **f)** $y = 18 - 2x^2$
g) $y = -3 - 3x^2$ **h)** $y = -5x^2 + 5$

7. Use a graphing calculator or graphing software to determine any x-intercepts, to the nearest tenth.

a) $y = x^2 - 2$ **b)** $y = -x^2 + 3$ **c)** $y = x^2 + 6$
d) $y = 2x^2 - 10$ **e)** $y = 8 - 4x^2$ **f)** $y = 0.5x^2 - 3$

Applications and Problem Solving

8. Communication If a function of the form $y = ax^2 + k$ has an x-intercept of 7.5, what is the other x-intercept? Explain how you know.

9. Geometry For triangles in which the base and the height are equal,
a) write an equation that relates the area, A, to the height, h
b) graph A versus h
c) find the h- and A-intercepts
d) state the domain and range

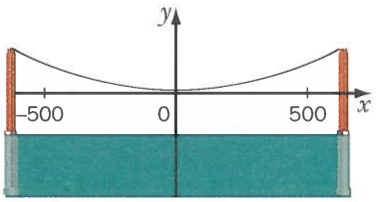
B

10. Write an equation for a parabola with the given vertex and given value of a.

a) (0, 0); $a = 5$ **b)** (0, 0); $a = -6$
c) (0, −7); $a = -8$ **d)** (0, 3); $a = 0.2$

11. Find the value of k so that the parabola $y = -2x^2 + k$ passes through the point (−3, −33).

12. Golden Gate Bridge The road on the Golden Gate Bridge is supported by two towers and the two cables that join them. The distance between the towers is 1280 m. Suppose the curve of a cable is graphed on a grid, with the origin on the road at the centre of the bridge. The curve made by the cable is a catenary that can be approximately modelled by the quadratic function



$$h = 0.000\,37d^2 + 2$$

where h metres is the height of the cable above the road, and d metres is the horizontal distance from the centre of the bridge.

a) Graph the function.
b) What is the distance from the road to the lowest point of the cable?
c) What is the maximum height of the towers above the road, to the nearest ten metres?
d) At a horizontal distance of 200 m from the centre of the bridge, how high is the cable above the road, to the nearest metre?

Applications and Problem Solving

8. Aerial flares Red aerial miniflares are used by some boaters in an emergency. The flight of one brand of flare, when fired at an angle of 70° to the horizontal, is modelled by the function

$$h = -9(t - 3)^2 + 83$$

where h is the height, in metres, and t is the time, in seconds, since the flare was fired.

a) What is the maximum height of the flare?

b) For how many seconds does the flare burn before it hits the water?

B

9. Write an equation for the parabola with the given vertex and the given value of a.

a) (7, 0); $a = 1$ **b)** (−5, 0); $a = -1$

c) (3, −5); $a = 2$ **d)** (6, 7); $a = -3$

e) (−1, −1); $a = -0.5$ **f)** (−8, 9); $a = 1.5$

10. Write an equation that defines each parabola.

a) congruent to $y = x^2$; opens up; vertex at (1, 5)

b) congruent to $y = x^2$; opens down; vertex at (−3, 0)

c) congruent to $y = 3x^2$; minimum at (4, −2)

d) congruent to $y = 2x^2$; maximum at (2, −3)

e) congruent to $y = 0.4x^2$; opens up; vertex at (−3, −3)

f) congruent to $y = 5x^2$; minimum at (4.5, 0)

g) congruent to $y = 4x^2$; maximum on the x-axis; axis of symmetry $x = 3$

h) congruent to $y = 2x^2$; minimum value −6; axis of symmetry $x = -5$

11. The vertex of a parabola is (−2, −4). One x-intercept is 7. What is the other x-intercept?

12. Communication The x-intercepts of a parabola are 5 and −7. What is the equation of the axis of symmetry? Explain.

13. Two points on a parabola are (4, −1) and (−10, −1). What is the equation of the axis of symmetry?

14. Baseball The following function gives the height, h metres, of a batted baseball as a function of the time, t seconds, since the ball was hit.

$$h = -6(t - 2.5)^2 + 38.5$$

a) What was the maximum height of the ball?

b) What was the height of the ball when it was hit?

c) How many seconds after it was hit did the ball hit the ground, to the nearest second?

d) Find the height of the ball 1 s after it was hit.

15. Soccer The equation shows the height of a soccer ball, h metres, as a function of the horizontal distance, d metres, the ball travels until it first hits the ground.

$$h = -0.025(d - 20)^2 + 10$$

a) What is the maximum height of the ball?
b) What is the horizontal distance of the ball from the kicker when it reaches its maximum height?
c) How far does the ball travel horizontally from when it is kicked until it hits the ground?
d) What is the height of the ball when it is 10 m horizontally from the kicker?
e) Communication Would an opposing player positioned under the path of the ball 34 m from the kicker be able to head the ball? Explain.
f) If the origin were placed at the vertex of the parabola, what would be the equation of the curve?

16. Touch football A touch football quarterback passed the ball to a receiver 40 m downfield. The path of the ball can be described by the function

$$h = -0.01(d - 20)^2 + 6$$

where h is the height of the ball, in metres, and d is the horizontal distance of the ball from the quarterback, in metres.
a) What was the maximum height of the ball?
b) What was the horizontal distance of the ball from the quarterback at its maximum height?
c) What was the height of the ball when it was thrown? when it was caught?
d) If a defensive back was 2 m in front of the receiver, how far was the defensive back from the quarterback?
e) How high would the defensive back have needed to reach to knock down the pass?

17. a) Sketch the graphs of each pair of functions. Compare the parabolas in each pair.
$y = (x - 1)^2$ and $y = (1 - x)^2$
$y = (x - 4)^2 - 2$ and $y = (4 - x)^2 - 2$
b) Explain your results by expanding $(x - h)^2$ and $(h - x)^2$.

18. Systems of equations a) Graph $y = 3x + 3$ and $y = (x + 2)^2 - 3$ on the same set of axes.
b) What are the coordinates of the intersection points?
c) Communication Describe how you found the intersection points.

19. The functions $y = m(x - 3)^2 + 1$ and $y = n(x - 2)^2 - 3$ are graphed on the same set of axes. How do m and n compare if the graphs both open up and
a) the graphs are congruent?
b) the first graph is narrower than the second?
c) the first graph is wider than the second?

20. Determine the value of k so that the graph of $y = (x + 3)^2 + k$ passes through the point (1, 20).

C

21. Write an equation for the parabola with the given vertex and passing through the given point.

a) vertex (−4, −5); point (−2, −1)
b) vertex (3, 2); point (1, −2)
c) vertex (1, 6); point (3, 2)
d) vertex (−2, 3); point (−1, 6)
e) vertex (−5, −3); point (−3, −11)
f) vertex (6, 4); point (8, 6)

22. Write an equation for each parabola, given the vertex and the y-intercept.

a) vertex (1, 2); y-intercept 4
b) vertex (−2, 3); y-intercept −1
c) vertex (2, −4); y-intercept −2
d) vertex (−4, −1); y-intercept −5

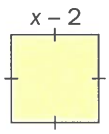
23. Find a and k so that the given points lie on the parabola.

a) $y = a(x - 1)^2 + k$; (2, 6), (3, 12)
b) $y = a(x + 3)^2 + k$; (−5, −8), (1, −20)
c) $y = a(x - 4)^2 + k$; (1, −13), (−1, −45)

24. Communication Describe the graph of $y = a(x - h)^2 + k$ if

a) $h = 0$ **b)** $k = 0$ **c)** $h = 0$ and $k = 0$

25. Geometry The area of a square is 3 square units greater than the area of the square shown.

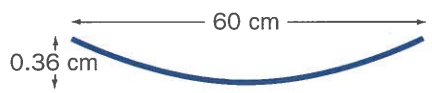


a) Write an equation that relates the area, A, of the larger square to the value of x.
b) Sketch a graph of A versus x for the larger square.
c) What value of x results in the minimum area for the larger square?
d) What is the area of the smaller square when the larger square has its minimum area?

26. Write the equation of the image of $y = 3(x - 2)^2 + 1$ that results from

a) a reflection in the x-axis
b) a reflection in the y-axis
c) a reflection in the y-axis, followed by a reflection in the x-axis

27. Astronomy British astronomer William Lassell used a telescope he built himself to discover a moon around Neptune in 1846, two moons around Uranus in 1851, and a moon around Saturn in 1858. The mirror from his telescope has a diameter of about 60 cm and a maximum depth of about 0.36 cm. A cross section of the mirror is in the shape of a parabola.



a) Suppose the origin of a coordinate grid is placed at the vertex, the y-axis is the axis of symmetry, and the units on the axes are centimetres. What are the coordinates of each end of the curve?
b) Write an equation for the curve.

Section 4.1 pp. 197–199

Practice **1. a)** function **b)** function **c)** not a function **d)** function **e)** function **f)** not a function **2. a)** 3 **b)** 23 **c)** −5 **d)** −13 **e)** −21 **f)** 395 **g)** −3 **h)** −7 **i)** 3995 **3. a)** 6 **b)** 2 **c)** −2 **d)** 14 **e)** 8 **f)** −12 **g)** 7 **h)** 8.2 **i)** 0 **4. a)** 9 **b)** 5 **c)** 9 **d)** 105 **e)** 105 **f)** 5.25 **g)** 5.01 **5. a)** 3 **b)** 1 **c)** 19 **d)** 163 **e)** 243 **f)** 1.5 **g)** 1.5 **6. b)** yes **7. a)** function **b)** not a function **c)** function **d)** not a function **8. a)** domain: {3, 4, 5, 6}, range: {−2, 0, 1, 3} **b)** domain: {−3, −1, 1, 3, 5}, range: {2, 3, 4} **c)** domain: {−2, −1, 0, 1}, range: {3, 4} **d)** domain: {−1}, range: {1, 2, 3, 4} **9. a)** domain: {−2, −1, 0, 1, 2}, range: {1, 2, 5}; function **b)** domain: {0, 1, 2, 3}, range: {−2, −1, 0, 1}; not a function **10. a)** domain: {−2, 0, 2, 4, 6}, range: {0, 2, 4, 6, 8} **b)** domain: set of real numbers, range: set of real numbers **c)** domain: set of real numbers, range: $y \leq 2$ **d)** domain: {1}, range: set of real numbers **11.** {2, 3, 6}

Applications and Problem Solving **12. a)** 2; 2.5 **b)** speed: independent, Mach number: dependent. The Mach number depends on the speed. **13. b)** 17.6 million **c)** 2039 **14. b)** No, the domain and range are both the set of real numbers. **c)** x does not have a minimum or maximum value. The domain is the set of real numbers. y has a minimum value of 0, but no maximum value. The range is the set of real numbers greater than 0. **15. a)** range: set of real numbers **b)** range: $y \geq -2$ **16. a)** ± 2 **b)** ± 4 **c)** 0 **d)** $\pm\sqrt{11}$ **17. a)** no **b)** Yes, there is only one name for every set of fingerprints. **18.** No, there are likely several people with the same first name. **19.** Since the x-coordinates of the points on a vertical line are all equal, if a vertical line passes through more than one point of the graph of a relation, then the relation contains two different points with the same x-coordinate, and so is not a function. **20. a)** $y = 8a + 3$ **b)** $y = -1 - 3n$ **c)** $y = m^2 - 2m + 2$ **d)** $y = 8k^2 + 8k - 1$ **e)** $y = 9t^2 + 6t - 4$ **f)** $y = 12w^2 - 32w + 25$ **21.** It is a vertical line. **22. 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)** It looks like steps. **c)** domain: $0 \leq t \leq 4$, range: {120, 200, 280, 360} **d)** (0.5, 120), (1, 120) **e)** (1, 120), (2, 200) **f)** No, the graph is a function.

Investigation pp. 200–203

1 Translations on a Coordinate Grid **1. a)** D′(2, 4), E′(−2, 4), F′(−2, −2) **b)** P′(−1, 4), Q′(−5, 6), R′(−7, −3) **c)** U′(−3, −4), V′(−1, 3), W′(0, 0) **d)** F′(4, −1), G′(−2, 6), H′(1, −2) **e)** A′(1, −3), B′(7, −4), C′(5, −7) **f)** J′(−1, −2), K′(−4, −1), L′(−6, −6) **2.** R(1, −4), S(−2, 3), T(−4, −5) **3. a)** A′(7, 3), B′(3, 8), C′(1, 4) **b)** A″(6, −2), B″(2, 3), C″(0, −1) **c)** 3 units to the right, 2 units downward

2 Reflections on a Coordinate Grid **1. a)** A′(2, −4), B′(1, −1), C′(6, −2) **b)** D′(0, −3), E′(5, −4), F′(2, 0) **c)** P′(1, −2), Q′(−3, 2), R′(3, 1) **2. a)** A′(−1, 3), B′(−2, 1), C′(−6, 3) **b)** D′(−1, 2), E′(0, −2), F′(−3, 1) **c)** P′(2, 1), Q′(3, −3), R′(−1, −2) **3. a)** (2, −3), (−2, 3) **b)** (−1, 2), (1, −2) **c)** (−3, −2), (3, 2) **d)** (4, 0), (−4, 0) **4.** A′(−1, 1), B′(−5, 2), C′(−3, 6) **5.** R′(2, −5), S′(−2, −4), T′(−1, 2) **6. a)** y-axis **b)** x-axis

3 Dilatations on a Coordinate Grid **1. a)** 2 **b)** $\frac{1}{3}$ **2. a)** A′(6, 4), B′(2, 8) **b)** C′(3, 2), D′(−1, 1) **c)** E′(−3, −3), F′(3, 6) **d)** G′(3, 1), H′(−2, 0) **3.** R′(6, 9), S′(−3, 12), T′(−9, −6) **4.** D′(3, 2), E′(−1, 3), F′(−2, −2), G′(2, −3) **5. b)** 8 **c)** P′(−6, 6), Q′(−6, −6), R′(6, −6) **d)** 72 **e)** P″(−1, 1), Q″(−1, −1), R″(1, −1) **f)** 2 **g)** 9:1; $\frac{1}{4}$:1 **h)** The first term is the square of the scale factor.

Section 4.2 pp. 213–216

Practice **1. a)** up; (0, 5); $x = 0$; domain: set of real numbers, range: $y \geq 5$; minimum: 5 **b)** up; (0, −2); $x = 0$; domain: set of real numbers, range: $y \geq -2$; minimum: −2 **c)** down; (0, −1); $x = 0$; domain: set of real numbers, range: $y \leq -1$; maximum: −1 **d)** down; (0, 4); $x = 0$; domain: set of real numbers, range: $y \leq 4$; maximum: 4 **e)** up; (0, 0); $x = 0$; domain: set of real numbers, range: $y \geq 0$; minimum: 0 **f)** down; (0, 0); $x = 0$; domain: set of real numbers, range: $y \leq 0$; maximum: 0 **g)** up; (0, −1); $x = 0$; domain: set of real numbers, range: $y \geq -1$; minimum: −1 **h)** down; (0, 0); $x = 0$; domain: set of real numbers, range: $y \leq 0$; maximum: 0 **i)** down; (0, −3); $x = 0$; domain: set of real numbers, range: $y \leq -3$; maximum: −3 **j)** up; (0, 1); $x = 0$; domain: set of real numbers, range: $y \geq 1$; minimum: 1 **k)** down; (0, 7); $x = 0$; domain: set of real numbers, range: $y \leq 7$; maximum: 7 **l)** down; (0, −6); $x = 0$; domain: set of real numbers, range: $y \leq -6$; maximum: −6 **2. a)** The graph of $y = x^2 - 4$ is a translation of the graph of $y = x^2$ 4 units downward **b)** The graph of $y = -x^2 + 5$ is a translation of the graph of $y = -x^2$ 5 units upward. **c)** The graph of $y = 3x^2$ is a vertical stretch of the graph of $y = x^2$ by a factor of 3. **d)** The graph of $y = -\frac{1}{3}x^2$ is a vertical shrink of the graph of $y = -x^2$ by a factor of $\frac{1}{3}$ **e)** The graph of $y = 2x^2 - 2$ is a translation of the graph of $y = 2x^2 + 7$ 9 units downward. **f)** The graph of

$y = -0.25x^2$ is a reflection of the graph of $y = 0.25x^2$ in the x-axis. **3. a)** $y = -2x^2 + 3$ **b)** $y = 2x^2 - 3$ **c)** $y = 2x^2 + 3$ **d)** $y = -2x^2 - 3$ **4. a)** down; (0, 0); domain: set of real numbers, range: $y \le 0$; maximum: 0 **b)** up; (0, −11.4); domain: set of real numbers, range: $y \ge -11.4$; minimum: −11.4 **c)** down; (0, 4.7); domain: set of real numbers, range: $y \le 4.7$; maximum: 4.7 **d)** up; (0, −3); domain: set of real numbers, range: $y \ge -3$; minimum: −3 **e)** down; (0, −8.3); domain: set of real numbers, range: $y \le -8.3$; maximum: −8.3 **f)** up; (0, 9.9); domain: set of real numbers, range: $y \ge 9.9$; minimum: 9.9 **g)** up; (0, 3.5); domain: set of real numbers, range: $y \ge 3.5$; minimum: 3.5 **h)** down; (0, −0.5); domain: set of real numbers, range: $y \le -0.5$; maximum: −0.5 **5. a)** It becomes the point (2, 13). **b)** It becomes the point (2, −1). **c)** It becomes the point (2, −2). **d)** It becomes the point (2, −2). **6. a)** (0, −9), x-intercepts: ±3, y-intercept: −9 **b)** (0, 1), x-intercepts: none, y-intercept: 1 **c)** (0, 4), x-intercepts: ±2, y-intercept: 4 **d)** (0, −8), x-intercepts: ±2, y-intercept: −8 **e)** (0, 16), x-intercepts: none, y-intercept: 16 **f)** (0, 18), x-intercepts: ±3, y-intercept: 18 **g)** (0, −3), x-intercepts: none, y-intercept: −3 **h)** (0, 5), x-intercepts: ±1, y-intercept: 5 **7. a)** ±1.4 **b)** ±1.7 **c)** no x-intercepts **d)** ±2.2 **e)** ±1.4 **f)** ±2.4

Applications and Problem Solving **8.** −7.5; The graph is symmetric about the y-axis. **9. a)** $A = \frac{1}{2}h^2$ **c)** 0, 0 **d)** domain: $h \ge 0$, range: $A \ge 0$ **10. a)** $y = 5x^2$ **b)** $y = -6x^2$ **c)** $y = -8x^2 - 7$ **d)** $y = 0.2x^2 + 3$ **11.** $k = -15$ **12. b)** 2 m **c)** 150 m **d)** 17 m **13. a)** (−3, 7), (2, 2) **b)** Answers may vary. **14. a)** $y = x^2 + 2$ **b)** $y = -x^2 - 1$ **c)** $y = 2x^2 - 3$ **d)** $y = -\frac{1}{2}x^2 + 4$ **15. a)** $n = 2p^2 - 4$ **b)** $n = -2p^2 + 4$ **c)** They are reflections of each other in the n-axis. **16. a)** $A = \pi r^2$ **c)** No, the domain of the function is $r \ge 0$. **d)** domain: $r \ge 0$, range: $A \ge 0$ **17. a)** $A = 400 - s^2$ **b)** 16 **d)** domain: $0 \le s \le 16$, range: $144 \le A \le 400$ **Technology Extension** Answers may vary.

Modelling Math p. 216

b) 1st quadrant; d and t must be non-negative. **c)** 5.4 s **d)** 13.5 s

Section 4.3 pp. 222–227

Practice **1. a)** up; (−5, 0); $x = -5$; domain: set of real numbers, range: $y \ge 0$; minimum: 0 **b)** down; (−1, 0); $x = -1$; domain: set of real numbers, range: $y \le 0$; maximum: 0 **c)** up; (3, 0); $x = 3$; domain: set of real numbers, range: $y \ge 0$; minimum: 0 **d)** up; (−2, 4); $x = -2$; domain: set of real numbers, range: $y \ge 4$; minimum: 4 **e)** down; (2, −5); $x = 2$; domain: set of real numbers, range: $y \le -5$; maximum: −5 **f)** up; (−3, −5); $x = -3$; domain: set of real numbers, range: $y \ge -5$; minimum: −5 **g)** up; (−6, 2); $x = -6$; domain: set of real numbers, range: $y \ge 2$; minimum: 2 **h)** up; (5, −4); $x = 5$; domain: set of real numbers, range: $y \ge -4$; minimum: −4 **i)** down; (−4, 3); $x = -4$; domain: set of real numbers, range: $y \le 3$; maximum: 3 **2. a)** up; (5, 0); $x = 5$; domain: set of real numbers, range: $y \ge 0$; minimum: 0 **b)** down; (−4, 0); $x = -4$; domain: set of real numbers, range: $y \le 0$; maximum: 0 **c)** up; (2, 1); $x = 2$; domain: set of real numbers, range: $y \ge 1$; minimum: 1 **d)** down; (−1, −2); $x = -1$; domain: set of real numbers, range: $y \le -2$; maximum: −2 **3. a)** up; vertically stretched by a factor of 2; (1, 0); $x = 1$; minimum: 0 **b)** down; vertically shrunk by a factor of 0.5; (−7, 0); $x = -7$; maximum: 0 **c)** down; vertically stretched by a factor of 2; (4, 7); $x = 4$; maximum: 7 **d)** up; vertically stretched by a factor of 4; (−3, −4); $x = -3$; minimum: −4 **e)** down; vertically stretched by a factor of 3; (5, 6); $x = 5$; maximum: 6 **f)** down; vertically shrunk by a factor of 0.4; (8, −1); $x = 8$; maximum: −1 **g)** up; vertically shrunk by a factor of $\frac{1}{3}$; (−6, −7); $x = -6$; minimum: −7 **h)** up; vertically shrunk by a factor of 0.5; (−1, −5); $x = -1$; minimum: −5 **i)** up; vertically stretched by a factor of 2.5; (−1.5, −9); $x = -1.5$; minimum: −9 **j)** down; vertically stretched by a factor of 1.2; (2.6, 3.3); $x = 2.6$; maximum: 3.3 **4. a)** $y = -3(x + 1)^2 + 2$ **b)** $y = 3(x - 1)^2 + 2$ **c)** $y = 3(x + 1)^2 - 2$ **d)** $y = -3(x - 1)^2 - 2$ **6. a)** x-intercept: 2; y-intercept: 4 **b)** x-intercepts: −5, 1; y-intercept: −5 **c)** x-intercepts: 2, 4; y-intercept: 8 **d)** x-intercepts: −3, −1; y-intercept: −3 **7. a)** x-intercepts: −2.7, 0.7; y-intercept: −2 **b)** x-intercepts: −0.4, 2.4; y-intercept: −2 **c)** x-intercepts: $\frac{1}{2}, \frac{3}{2}$; y-intercept: −3 **d)** x-intercepts: none; y-intercept: −47 **e)** x-intercept: −4; y-intercept: 4 **f)** x-intercepts: −5, −1; y-intercept: −2.5

Applications and Problem Solving **8. a)** 83 m **b)** 6.0 s **9. a)** $y = (x - 7)^2$ **b)** $y = -(x + 5)^2$ **c)** $y = 2(x - 3)^2 - 5$ **d)** $y = -3(x - 6)^2 + 7$ **e)** $y = -0.5(x + 1)^2 - 1$ **f)** $y = 1.5(x + 8)^2 + 9$ **10. a)** $y = (x - 1)^2 + 5$ **b)** $y = -(x + 3)^2$ **c)** $y = 3(x - 4)^2 - 2$ **d)** $y = -2(x - 2)^2 - 3$ **e)** $y = 0.4(x + 3)^2 - 3$ **f)** $y = 5(x - 4.5)^2$ **g)** $y = -4(x - 3)^2$ **h)** $y = 2(x + 5)^2 - 6$ **11.** −11 **12.** $x = -1$; The axis of symmetry is halfway between the x-intercepts. It is the vertical line passing through

the midpoint of the line segment joining the x-intercepts. **13.** $x = -3$ **14. a)** 38.5 m **b)** 1 m **c)** 5 s **d)** 25 m **15. a)** 10 m **b)** 20 m **c)** 40 m **d)** 7.5 m **e)** No, the ball would be at a height of 5.1 m, which is too high to jump. **f)** $h = -0.025d^2$ **16. a)** 6 m **b)** 20 m **c)** 2 m; 2 m **d)** 38 m **e)** 2.76 m **17. a)** The graphs in each pair are identical. **b)** $(x - h)^2 = (h - x)^2$ **18. b)** $(-2, -3)$, $(1, 6)$ **c)** Answers may vary. **19. a)** $m = n$ **b)** $m > n$ **c)** $m < n$ **20.** $k = 4$ **21. a)** $y = (x + 4)^2 - 5$ **b)** $y = -(x - 3)^2 + 2$ **c)** $y = -(x - 1)^2 + 6$ **d)** $y = 3(x + 2)^2 + 3$ **e)** $y = -2(x + 5)^2 - 3$ **f)** $y = \frac{1}{2}(x - 6)^2 + 4$ **22. a)** $y = 2(x - 1)^2 + 2$ **b)** $y = -(x + 2)^2 + 3$ **c)** $y = \frac{1}{2}(x - 2)^2 - 4$ **d)** $y = -\frac{1}{4}(x + 4)^2 - 1$ **23. a)** $a = 2$, $k = 4$ **b)** $a = -1$, $k = -4$ **c)** $a = -2$, $k = 5$ **24. a)** vertex on y-axis **b)** vertex on x-axis **c)** vertex at $(0, 0)$ **25. a)** $A = (x - 2)^2 + 3$ **c)** $x = 2$ **d)** 0 **26. a)** $y = -3(x - 2)^2 - 1$ **b)** $y = 3(x + 2)^2 + 1$ **c)** $y = -3(x + 2)^2 - 1$ **27. a)** $(\pm 30, 0.36)$ **b)** $y = 0.0004x^2$ **c)** $y = 0.0004(x + 30)^2 - 0.36$ **d)** $y = 0.0004(x - 30)^2 - 0.36$ **e)** 0.16 cm **Technology Extension** Answers may vary.

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Practice 1. a) 49 **b)** 36 **c)** 1 **d)** 81 **e)** 25 **f)** 100 **2. a)** $y = (x + 3)^2 - 6$; $(-3, -6)$, $x = -3$; Points may vary. $(0, 3)$, $(1, 10)$ **b)** $y = (x - 2)^2 - 5$; $(2, -5)$, $x = 2$; Points may vary. $(0, -1)$, $(1, -4)$ **c)** $y = (x + 5)^2 + 5$; $(-5, 5)$, $x = -5$; Points may vary. $(0, 30)$, $(1, 41)$ **d)** $y = (x - 1)^2 + 2$; $(1, 2)$, $x = 1$; Points may vary. $(0, 3)$, $(2, 3)$ **e)** $y = (x + 6)^2 - 8$; $(-6, -8)$, $x = -6$; Points may vary. $(0, 28)$, $(1, 41)$ **f)** $y = (x - 4)^2 - 4$; $(4, -4)$, $x = 4$; Points may vary. $(0, 12)$, $(1, 5)$ **3. a)** $y = x^2 - 4$ **b)** $y = -x^2 + 4x$ **c)** $y = x^2 - 4x$ **d)** $y = x^2 + 4x$ **e)** $y = -x^2 + 4$ **f)** $y = -x^2 - 4x$ **4. a)** $(1, -9)$; $x = 1$; x-intercepts: -2, 4; y-intercept: -8; $y \geq -9$ **b)** $(3, 1)$; $x = 3$; x-intercepts: none; y-intercept: 10; $y \geq 1$ **c)** $(-2, -4)$; $x = -2$; x-intercepts: -4, 0; y-intercept: 0; $y \geq -4$ **d)** $(6, 4)$; $x = 6$; x-intercepts: none; y-intercept: 40; $y \geq 4$ **5. a)** $y = -(x - 4)^2 + 5$; $(4, 5)$; $x = 4$. Points may vary: $(0, -11)$, $(1, -4)$ **b)** $y = -(x + 4)^2 + 9$; $(-4, 9)$; $x = -4$. Points may vary. $(0, -7)$, $(1, -16)$ **c)** $y = -(x + 2)^2 - 3$; $(-2, -3)$; $x = -2$. Points may vary. $(0, -7)$, $(1, -12)$ **d)** $y = -(x + 1)^2 + 1$; $(-1, 1)$; $x = -1$; Points may vary. $(0, 0)$, $(1, -3)$ **6. a)** $(-1, 4)$; $x = -1$; x-intercepts: -3, 1; y-intercept: 3; $y \leq 4$ **b)** $(-2, -8)$; $x = -2$; x-intercepts: none; y-intercept: -12; $y \leq -8$ **c)** $(4, 4)$; $x = 4$; x-intercepts: 2, 6; y-intercept: -12; $y \leq 4$ **d)** $(5, 0)$; $x = 5$; x-intercept: 5; y-intercept: -25; $y \leq 0$ **7. a)** minimum: -7 **b)** maximum: 5 **c)** maximum: 16 **d)** minimum: 0 **e)** minimum: -30 **f)** maximum: 13 **g)** minimum: -28 **h)** maximum: -3 **8. a)** $y = 3(x + 1)^2 - 11$; $(-1, -11)$; $x = -1$; $y \geq -11$ **b)** $y = -2(x + 3)^2 + 18$; $(-3, 18)$; $x = -3$; $y \leq 18$ **c)** $y = 2(x - 1)^2 + 3$; $(1, 3)$; $x = 1$; $y \geq 3$ **d)** $y = -4(x - 1)^2 - 3$; $(1, -3)$; $x = 1$; $y \leq -3$ **e)** $y = 4(x - 2)^2 - 16$; $(2, -16)$; $x = 2$; $y \geq -16$ **f)** $y = -3(x - 2)^2 - 2$; $(2, -2)$; $x = 2$; $y \leq -2$ **9. a)** minimum: 1 at $x = -1$ **b)** maximum: 6 at $x = 5$ **c)** maximum: 7 at $x = -3$ **d)** maximum: -1 at $x = 3$ **e)** minimum: -2 at $x = 2$ **f)** minimum: 2 at $x = 1$ **g)** maximum: 8 at $x = 2$ **h)** maximum: 0 at $x = 1$ **Applications and Problem Solving 10.** 5, -5 **11.** 17, 17 **12. a)** minimum: -14 at $x = -2$ **b)** minimum: -9 at $x = -10$ **c)** maximum: 5 at $x = -5$ **d)** minimum: -5 at $x = 2$ **e)** maximum: 5 at $x = 4$ **f)** maximum: 20 at $x = 100$ **g)** minimum: 1.5 at $x = -1$ **h)** maximum: -0.5 at $x = 3$ **13. a)** $(-2, -1)$ **b)** $(1, -9)$ **c)** $(\frac{3}{4}, -\frac{25}{8})$ **d)** $(-1, 12)$ **14. a)** 20 m **b)** 100 m **c)** 200 m **15. a)** 4.25 m **b)** 5 m **c)** 2 m **16. a)** 46 m **b)** 480 m **c)** 17 m **17. a)** 84 m **b)** 75 m **c)** 71 m **18. a)** 100 m by 100 m **b)** 10 000 m^2 **19.** 15 m **20.** \$30 **21.** 12.5 cm^2 **22. a)** 123.6 m **b)** 7 s **23. a)** The x-coordinates are both 0; the y-coordinates are opposites. **b)** opposite **24. a)** The graph is a straight line. **b)** The graph is a parabola with the y-axis as its axis of symmetry. **25. a)** $k = 9$ **b)** $k < 9$ **c)** $k > 9$ **26. a)** $k = -8$ **b)** $k > -8$ **c)** $k < -8$ **Technology Extension** Answers may vary.

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1. a) $R = (2000 - 100x)(8 + x)$ **b)** (6, 19 600) **c)** \$14 **d)** 1400 **2. a)** People will stop buying because of high price. **b)** People will stop buying because of poor quality.

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a) Earth: 22 m; Mars: 52 m; Pluto: 402 m
b) Earth: 2 s; Mars: 5 s; Pluto: 40 s

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1. a) $y = x(x - 4) - 1$ **b)** $y = x(x - 8) + 6$ **c)** $y = 3x(x - 4) + 4$ **d)** $y = 2x(x - 2) + 3$ **e)** $y = x(x + 2) - 5$ **f)** $y = x(x + 6) + 7$ **g)** $y = 2x(x + 6) - 2$ **h)** $y = -x(x - 4) - 2$ **i)** $y = -4x(x - 2) + 1$ **j)** $y = -2x(x + 2) - 3$

2. Substituting $x = 0$ and $x = s$ into the equation shows that $(0, t)$ and (s, t) are two points on the parabola. Thus, the x-coordinate of the vertex is $\frac{s}{2}$.

Substituting $x = \frac{s}{2}$ into the equation and