Practice

A

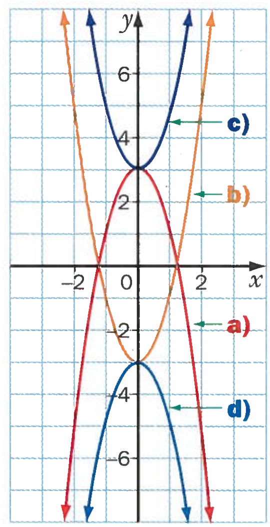
1. Sketch the graph of each parabola and state the direction of the opening, the coordinates of the vertex, the equation of the axis of symmetry, the domain and range, and the maximum or minimum value.

a) $y = x^2 + 5$ **b)** $y = x^2 - 2$ **c)** $y = -x^2 - 1$ **d)** $y = -x^2 + 3$
e) $y = 3x^2$ **f)** $y = -4x^2$ **g)** $y = 2 + x^2$ **h)** $y = -1.5x^2$
i) $y = -2x^2 - 3$ **j)** $y = 0.5x^2 + 1$ **k)** $y = -0.5x^2 + 7$ **l)** $y = -3x^2 - 6$

2. Communication Write one sentence that compares each pair of graphs.

a) $y = x^2$ and $y = x^2 - 4$ **b)** $y = -x^2$ and $y = -x^2 + 5$
c) $y = x^2$ and $y = 3x^2$ **d)** $y = -x^2$ and $y = -\frac{1}{3}x^2$
e) $y = 2x^2 + 7$ and $y = 2x^2 - 2$ **f)** $y = 0.25x^2$ and $y = -0.25x^2$

3. The four graphs represent the four equations $y = 2x^2 - 3$, $y = -2x^2 - 3$, $y = 2x^2 + 3$, and $y = -2x^2 + 3$. Match each graph with the correct equation.



4. Without graphing each function, state the direction of the opening, the coordinates of the vertex, the domain and range, and the maximum or minimum value.

a) $y = -5x^2$ **b)** $y = x^2 - 11.4$
c) $y = -x^2 + 4.7$ **d)** $y = 2x^2 - 3$
e) $y = -2.9x^2 - 8.3$ **f)** $y - 9.9 = 1.6x^2$
g) $3.5 + 2.2x^2 = y$ **h)** $4.3x^2 + y = -0.5$

5. Communication Describe what happens to the point (2, 4) on the graph of $y = x^2$ when each pair of transformations is applied to the parabola in the given order.

a) a vertical stretch of scale factor 2, followed by a vertical translation of 5
b) a reflection in the x-axis, followed by a vertical translation of 3
c) a reflection in the x-axis, followed by a vertical shrink of scale factor $\frac{1}{2}$
d) a vertical translation of –2, followed by a reflection in the x-axis

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

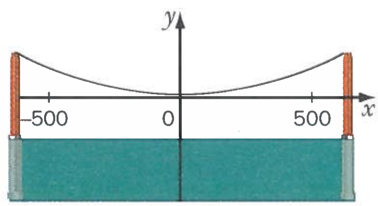
B

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?

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: $y \le 2$ **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: $y \ge -2$ **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: $0 \le t \le 4$, 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: $y \ge 5$; minimum: 5 **b)** up; (0, −2); $x = 0$; domain: set of real numbers, range: $y \ge -2$; minimum: −2 **c)** down; (0, −1); $x = 0$; domain: set of real numbers, range: $y \le -1$; maximum: −1 **d)** down; (0, 4); $x = 0$; domain: set of real numbers, range: $y \le 4$; maximum: 4 **e)** up; (0, 0); $x = 0$; domain: set of real numbers, range: $y \ge 0$; minimum: 0 **f)** down; (0, 0); $x = 0$; domain: set of real numbers, range: $y \le 0$; maximum: 0 **g)** up; (0, −1); $x = 0$; domain: set of real numbers, range: $y \ge -1$; minimum: −1 **h)** down; (0, 0); $x = 0$; domain: set of real numbers, range: $y \le 0$; maximum: 0 **i)** down; (0, −3); $x = 0$; domain: set of real numbers, range: $y \le -3$; maximum: −3 **j)** up; (0, 1); $x = 0$; domain: set of real numbers, range: $y \ge 1$; minimum: 1 **k)** down; (0, 7); $x = 0$; domain: set of real numbers, range: $y \le 7$; maximum: 7 **l)** down; (0, −6); $x = 0$; domain: set of real numbers, range: $y \le -6$; 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: $y \leq 0$; maximum: 0 **b)** up; (0, −11.4); domain: set of real numbers, range: $y \geq -11.4$; minimum: −11.4 **c)** down; (0, 4.7); domain: set of real numbers, range: $y \leq 4.7$; maximum: 4.7 **d)** up; (0, −3); domain: set of real numbers, range: $y \geq -3$; minimum: −3 **e)** down; (0, −8.3); domain: set of real numbers, range: $y \leq -8.3$; maximum: −8.3 **f)** up; (0, 9.9); domain: set of real numbers, range: $y \geq 9.9$; minimum: 9.9 **g)** up; (0, 3.5); domain: set of real numbers, range: $y \geq 3.5$; minimum: 3.5 **h)** down; (0, −0.5); domain: set of real numbers, range: $y \leq -0.5$; 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: $h \geq 0$, range: $A \geq 0$ **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 $r \geq 0$. **d)** domain: $r \geq 0$, range: $A \geq 0$
17. a) $A = 400 - s^2$ **b)** 16 **d)** domain: $0 \leq s \leq 16$, range: $144 \leq A \leq 400$ **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: $y \geq 0$; minimum: 0 **b)** down; (−1, 0); $x = -1$; domain: set of real numbers, range: $y \leq 0$; maximum: 0 **c)** up; (3, 0); $x = 3$; domain: set of real numbers, range: $y \geq 0$; minimum: 0 **d)** up; (−2, 4); $x = -2$; domain: set of real numbers, range: $y \geq 4$; minimum: 4 **e)** down; (2, −5); $x = 2$; domain: set of real numbers, range: $y \leq -5$; maximum: −5 **f)** up; (−3, −5); $x = -3$; domain: set of real numbers, range: $y \geq -5$; minimum: −5 **g)** up; (−6, 2); $x = -6$; domain: set of real numbers, range: $y \geq 2$; minimum: 2 **h)** up; (5, −4); $x = 5$; domain: set of real numbers, range: $y \geq -4$; minimum: −4 **i)** down; (−4, 3); $x = -4$; domain: set of real numbers, range: $y \leq 3$; maximum: 3 **2. a)** up; (5, 0); $x = 5$; domain: set of real numbers, range: $y \geq 0$; minimum: 0 **b)** down; (−4, 0); $x = -4$; domain: set of real numbers, range: $y \leq 0$; maximum: 0 **c)** up; (2, 1); $x = 2$; domain: set of real numbers, range: $y \geq 1$; minimum: 1 **d)** down; (−1, −2); $x = -1$; domain: set of real numbers, range: $y \leq -2$; 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