Practice

A

1. Find the value of c that will make each expression a perfect square trinomial.

a) $x^2 + 14x + c$ **b)** $x^2 - 12x + c$

c) $x^2 - 2x + c$ **d)** $x^2 + 18x + c$

e) $x^2 - 10x + c$ **f)** $x^2 + 20x + c$

2. Write each function in the form $y = a(x - h)^2 + k$. Sketch the graph, showing the coordinates of the vertex, the equation of the axis of symmetry, and the coordinates of two other points on the graph.

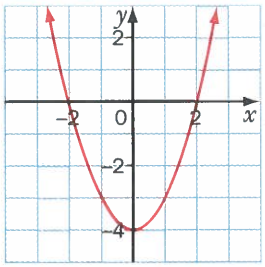
a) $y = x^2 + 6x + 3$ **b)** $y = x^2 - 4x - 1$

c) $y = x^2 + 10x + 30$ **d)** $y = x^2 - 2x + 3$

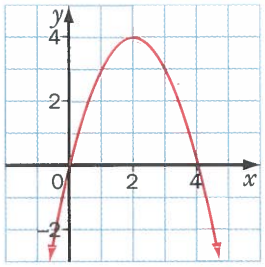
e) $y = 28 + 12x + x^2$ **f)** $y = 12 - 8x + x^2$

3. The six graphs represent the six equations $y = x^2 + 4x$, $y = x^2 - 4x$, $y = -x^2 + 4x$, $y = -x^2 - 4x$, $y = x^2 - 4$, and $y = -x^2 + 4$. Match each graph with the correct equation.

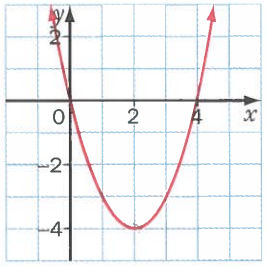
a)



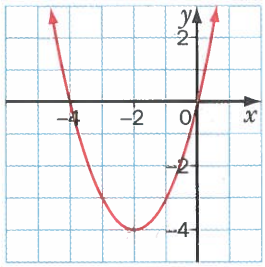
b)



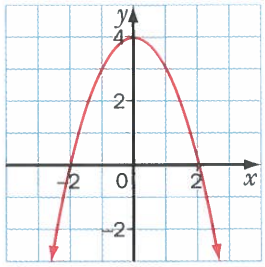
c)



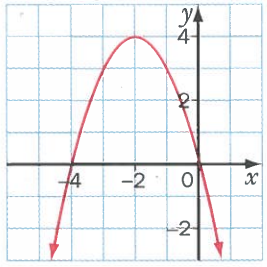
d)



e)



f)



4. Sketch the graph of each function. Show the coordinates of the vertex, the equation of the axis of symmetry, and any intercepts. State the range.

a) $y = x^2 - 2x - 8$ **b)** $y = x^2 - 6x + 10$

c) $y = x^2 + 4x$ **d)** $y = 40 - 12x + x^2$

5. Write each function in the form $y = a(x - h)^2 + k$. Sketch the graph, showing the coordinates of the vertex, the equation of the axis of symmetry, and the coordinates of two other points on the graph.

a) $y = -x^2 + 8x - 11$ **b)** $y = -x^2 - 8x - 7$

c) $y = -x^2 - 4x - 7$ **d)** $y = -2x - x^2$

6. Sketch the graph of each function. Show the coordinates of the vertex, the equation of the axis of symmetry, and any intercepts. State the range.

a) $y = -x^2 - 2x + 3$ **b)** $y = -x^2 - 4x - 12$

c) $y = -x^2 + 8x - 12$ **d)** $y = 10x - 25 - x^2$

7. Without graphing each function, state whether it has a maximum or a minimum. Give the maximum or minimum value of the function.

a) $y = x^2 + 6x + 2$ **b)** $y = -x^2 - 4x + 1$

c) $y = -x^2 + 8x$ **d)** $y = x^2 - 12x + 36$

e) $y = x^2 + 10x - 5$ **f)** $y = 4 - 6x - x^2$

g) $y - 21 = x^2 - 14x$ **h)** $y = 10x - 28 - x^2$

8. Write each function in the form $y = (x - h)^2 + k$. Then, graph the function. Show the coordinates of the vertex and the equation of the axis of symmetry. State the range.

a) $y = 3x^2 + 6x - 8$ **b)** $y = -2x^2 - 12x$

c) $y = 2x^2 - 4x + 5$ **d)** $y = -4x^2 + 8x - 7$

e) $y = 4x^2 - 16x$ **f)** $y = -3x^2 + 12x - 14$

9. State the maximum or minimum value of y and the value of x when it occurs.

a) $y = 2x^2 + 4x + 3$ **b)** $y = -2x^2 + 20x - 44$

c) $y = -4x^2 - 24x - 29$ **d)** $y = -3x^2 + 18x - 28$

e) $y = 5x^2 - 20x + 18$ **f)** $y = 10x^2 - 20x + 12$

g) $y = 8x - 2x^2$ **h)** $y = -4x^2 + 8x - 4$

Applications and Problem Solving

B

10. Find two numbers whose difference is 10 and whose product is a minimum.

11. Find two numbers whose sum is 34 and whose product is a maximum.

12. State the maximum or minimum value of y and the value of x when it occurs.

a) $y = 1.5x^2 + 6x - 8$ **b)** $y = 0.1x^2 + 2x + 1$

c) $y = -0.2x^2 - 2x$ **d)** $y = 1.25x^2 - 5x$

e) $y = -2.5x^2 + 20x - 35$ **f)** $y = -0.003x^2 + 0.6x - 10$

g) $y = 0.5x^2 + x + 2$ **h)** $y = -0.5x^2 + 3x - 5$

13. Sketch the graph of each function. State the coordinates of the vertex.

a) $y = (x + 1)(x + 3)$ **b)** $y = (x + 2)(x - 4)$

c) $y = (2x + 1)(x - 2)$ **d)** $y = -3(x - 1)(x + 3)$

14. Golf The path of the ball for many golf shots can be modelled by a quadratic function. The path of a golf ball hit at an angle of about 10° to the horizontal can be modelled by the function

$$h = -0.002d^2 + 0.4d$$

where h is the height of the ball, in metres, and d is the horizontal distance the ball travels, in metres, until it first hits the ground.

a) What is the maximum height reached by the ball?

b) What is the horizontal distance of the ball from the golfer when the ball reaches its maximum height?

c) What distance does the ball travel horizontally until it first hits the ground?

15. Basketball The path of a basketball shot can be modelled by the equation

$$h = -0.09d^2 + 0.9d + 2$$

where h is the height of the basketball, in metres, and d is the horizontal distance of the ball from the player, in metres.

a) What is the maximum height reached by the ball?

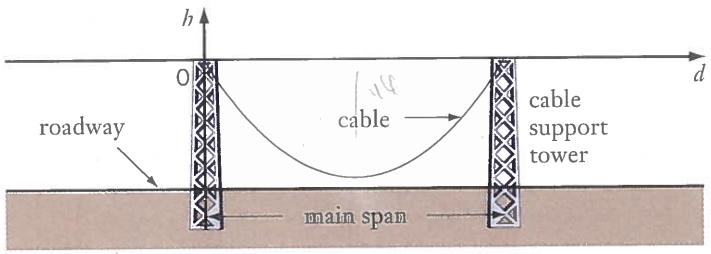
b) What is the horizontal distance of the ball from the player when it reaches its maximum height?

c) How far from the floor is the ball when the player releases it?

16. Brooklyn Bridge The Brooklyn Bridge in New York City is a suspension bridge that crosses the East River and connects Brooklyn to the island of Manhattan. If the origin is placed at the top of one of the cable-support towers, as shown, the shape of a cable that supports the main span can be modelled by the equation

$$h = 0.0008d^2 - 0.384d$$

where h metres represents the height and d metres represents the horizontal distance.



a) What is the vertical distance from the top of a support tower to the lowest point on a cable, to the nearest metre?

b) What is the length of the main span?

c) At a horizontal distance of 50 m from one end of the cable, how far is the cable below the top of the support towers, to the nearest metre?

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.

Section 4.4 pp. 234–239

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.

Career Connection p. 239

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.

Modelling Math p. 240

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

Section 4.5 p. 241

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