$$-16t^2 + 48t + 8 = 0$$

$$-2t^2 + 6t + 1 = 0 \qquad \text{• Divide each side by 8.}$$

$$t = \frac{-(6) \pm \sqrt{6^2 - 4(-2)(1)}}{2(-2)} \qquad \text{• Use the quadratic formula.}$$

$$= \frac{-6 \pm \sqrt{44}}{-4} = \frac{-3 \pm \sqrt{11}}{-2}$$

TO REVIEW

Quadratic Formula
See page 100.

Using a calculator to approximate the positive root, we find that the ball will hit the ground in $t \approx 3.16$ seconds. This is also the value of the t-coordinate of the t-intercept in Figure 2.61.

▸ **Try Exercise 70, page 209**

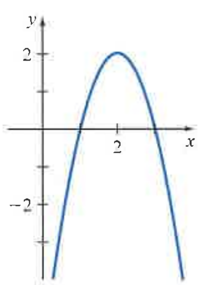
Answers to Exercises 9–18 and 25–28 are on pages AA5–AA6.

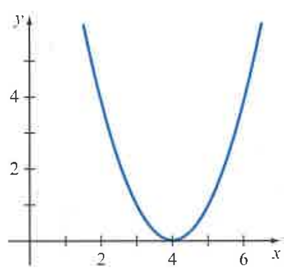
EXERCISE SET 2.4

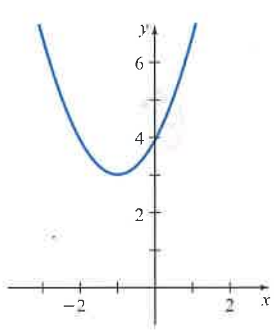
Concept Check

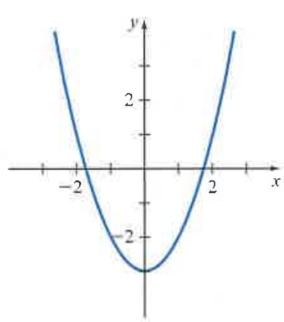
In Exercises 1 to 8, match each graph in *a.* through *h.* with the proper quadratic function.

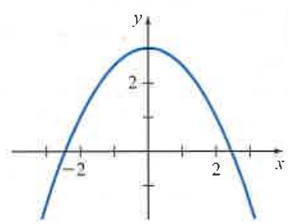
1. $f(x) = x^2 - 3$ d
2. $f(x) = x^2 + 2$ f
3. $f(x) = (x - 4)^2$ b
4. $f(x) = (x + 3)^2$ h
5. $f(x) = -2x^2 + 2$ g
6. $f(x) = -\frac{1}{2}x^2 + 3$ e
7. $f(x) = (x + 1)^2 + 3$ c
8. $f(x) = -2(x - 2)^2 + 2$ a

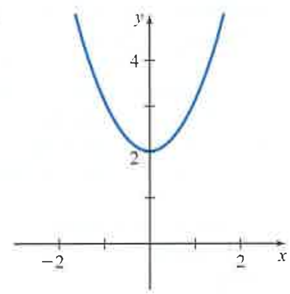
a.


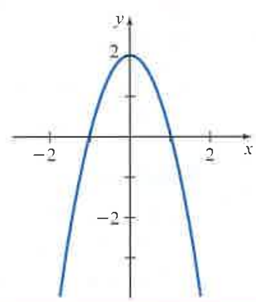
b.


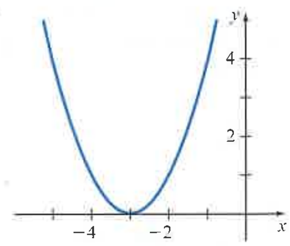
c.


d.


e.


f.


g.


h.


In Exercises 9 to 18, use the method of completing the square to find the standard form of the quadratic function. State the vertex and axis of symmetry of the graph of the function and then sketch its graph.

9. $f(x) = x^2 + 4x + 1$
10. $f(x) = x^2 + 6x - 1$
11. $f(x) = x^2 - 8x + 5$
12. $f(x) = x^2 - 10x + 3$
13. $f(x) = x^2 + 3x + 1$
14. $f(x) = x^2 + 7x + 2$
15. $f(x) = -x^2 + 4x + 2$
16. $f(x) = -x^2 - 2x + 5$
17. $f(x) = -3x^2 + 3x + 7$
18. $f(x) = -2x^2 - 4x + 5$

Indicates Try It Exercises

In Exercises 19 to 28, use the vertex formula to determine the vertex of the graph of the function and write the function in standard form.

19. $f(x) = x^2 - 10x$
Vertex: $(5, -25)$, $f(x) = (x - 5)^2 - 25$

20. $f(x) = x^2 - 6x$
Vertex: $(3, -9)$, $f(x) = (x - 3)^2 - 9$

21. $f(x) = x^2 - 10$
Vertex: $(0, -10)$, $f(x) = x^2 - 10$

22. $f(x) = x^2 - 4$
Vertex: $(0, -4)$, $f(x) = x^2 - 4$

23. $f(x) = -x^2 + 6x + 1$
Vertex: $(3, 10)$, $f(x) = -(x - 3)^2 + 10$

24. $f(x) = -x^2 + 4x + 1$
Vertex: $(2, 5)$, $f(x) = -(x - 2)^2 + 5$

25. $f(x) = 2x^2 - 3x + 7$
Answer on page AA6.

26. $f(x) = 3x^2 - 10x + 2$
Answer on page AA6.

27. $f(x) = -4x^2 + x + 1$
Answer on page AA6.

28. $f(x) = -5x^2 - 6x + 3$
Answer on page AA6.

29. Find the range of $f(x) = x^2 - 2x - 1$.
$\{y | y \geq -2\}$

30. Find the range of $f(x) = -x^2 - 6x - 2$.
$\{y | y \leq 7\}$

31. Find the range of $f(x) = -2x^2 + 5x - 1$. $\left\{y \middle| y \leq \frac{17}{8}\right\}$

32. Find the range of $f(x) = 2x^2 + 6x - 5$. $\left\{y \middle| y \geq -\frac{19}{2}\right\}$

In Exercises 33 to 36, find the real zeros of *f* and the *x*-intercepts of the graph of *f*.

33. $f(x) = x^2 + 2x - 24$
-6 and 4; $(-6, 0)$ and $(4, 0)$

34. $f(x) = -x^2 + 6x + 7$
-1 and 7; $(-1, 0)$ and $(7, 0)$

35. $f(x) = 2x^2 + 11x + 12$
-4 and $-\frac{3}{2}$; $(-4, 0)$ and $\left(-\frac{3}{2}, 0\right)$

36. $f(x) = 2x^2 - 9x + 10$
2 and $\frac{5}{2}$; $(2, 0)$ and $\left(\frac{5}{2}, 0\right)$

In Exercises 37 to 46, find the maximum or minimum value of the function. State whether this value is a maximum or a minimum.

37. $f(x) = x^2 + 8x$
-16, minimum

38. $f(x) = -x^2 - 6x$
9, maximum

39. $f(x) = -x^2 + 6x + 2$
11, maximum

40. $f(x) = -x^2 + 10x - 3$
22, maximum

41. $f(x) = 2x^2 + 3x + 1$
$-\frac{1}{8}$, minimum

42. $f(x) = 3x^2 + x - 1$
$-\frac{13}{12}$, minimum

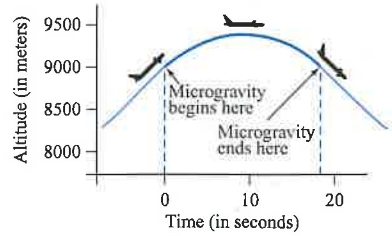
43. $f(x) = 5x^2 - 11$
-11, minimum

44. $f(x) = 3x^2 - 41$
-41, minimum

45. $f(x) = -\frac{1}{2}x^2 + 6x + 17$ 35, maximum

46. $f(x) = -\frac{3}{4}x^2 - \frac{2}{5}x + 7$ $\frac{529}{75} = 7\frac{4}{75}$, maximum

47. Astronaut Training To prepare astronauts for the experience of zero gravity (technically, microgravity) in space, NASA uses a specially designed jet. A pilot accelerates the plane upward to an altitude of approximately 9000 meters and then reduces power. During the time of reduced power, the plane is in freefall and the astronauts experience microgravity. The altitude $A(t)$, in meters, of the plane t seconds after power was reduced can be approximated by $A(t) = -4.9t^2 + 90t + 9000$. The graph is shown as follows.



If the pilot increases power when the plane descends to 9000 meters, ending microgravity, find the time the astronauts experience microgravity during one of these maneuvers. Round to the nearest tenth of a second. 18.4 s

48. Soccer Ball Kick The height $h(t)$, in meters, above the ground of a certain soccer ball kick t seconds after the ball is kicked can be approximated by $h(t) = -4.9t^2 + 12.8t$. Determine the time for which the ball is in the air. Round to the nearest tenth of a second. 2.6 s

49. Height of an Arch The height of an arch is given by

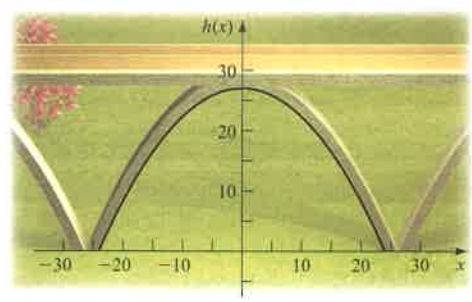
$$h(x) = -\frac{3}{64}x^2 + 27, \quad -24 \leq x \leq 24$$

where $|x|$ is the horizontal distance in feet from the center of the arch to the ground.

a. What is the maximum height of the arch? 27 ft

b. What is the height of the arch 10 feet to the right of center?

c. How far from the center is the arch 8 feet tall? $22\frac{5}{16}$ ft ≈ 20.1 ft from the center



50. Geometry The sum of the length l and the width w of a rectangular area is 240 meters.

a. Write w as a function of l. $w = 240 - l$

b. Write the area A as a function of l. $A = 240l - l^2$

c. Find the dimensions that produce the greatest area. $l = 120$ m, $w = 120$ m

51. Rectangular Enclosure A veterinarian uses 600 feet of chain-link fencing to enclose a rectangular region and to subdivide the region into two smaller rectangular regions by placing a fence parallel to one of the sides, as shown in the figure.

a. Write the width w as a function of the length l. $w = \frac{600 - 2l}{3}$

b. Write the total area A as a function of l. $A = 200l - \frac{2}{3}l^2$

c. Find the dimensions that produce the greatest enclosed area. $w = 100$ ft, $l = 150$ ft