Answers to Exercises 1–6, 11–16, 49–54, and 59–82 are on pages AA6–AA8.

EXERCISE SET 2.5

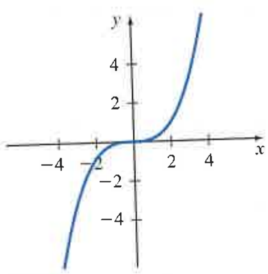
Concept Check

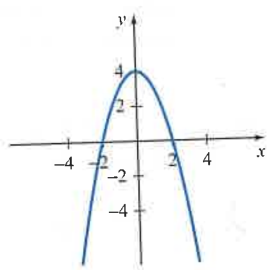
In Exercises 1 to 6, plot the image of the given point with respect to

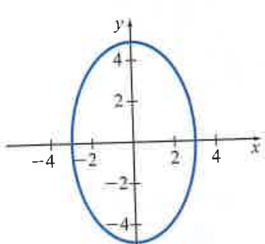
a. the *y*-axis. Label this point *A*.
b. the *x*-axis. Label this point *B*.
c. the origin. Label this point *C*.

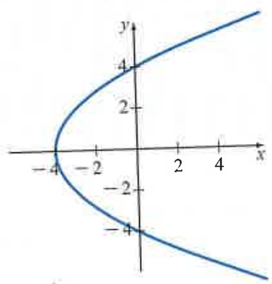
1. $P(5, -3)$
2. $Q(-4, 1)$
3. $R(-2, 3)$
4. $S(-5, 3)$
5. $T(-4, -5)$
6. $U(5, 1)$

In Exercises 7 to 10, determine whether the graph is symmetric with respect to the *x*-axis, the *y*-axis, the origin, or none of these. A graph may have more than one type of symmetry.

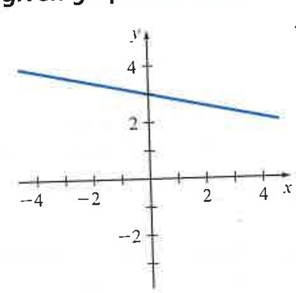
7.

Origin

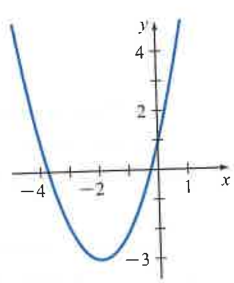
8.

y-axis

9.

x-axis, *y*-axis, Origin

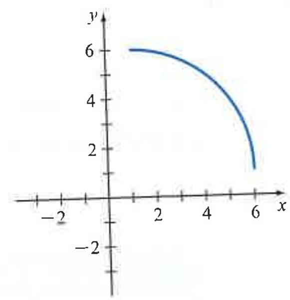
10.

x-axis

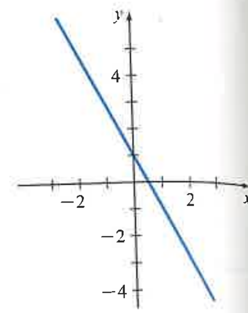
In Exercises 11 and 12, sketch a graph that is symmetric to the given graph with respect to the *x*-axis.

11.


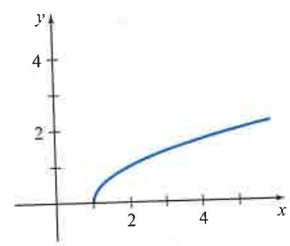
12.


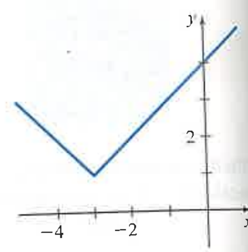
In Exercises 13 and 14, sketch a graph that is symmetric to the given graph with respect to the *y*-axis.

13.


14.


In Exercises 15 and 16, sketch a graph that is symmetric to the given graph with respect to the origin.

15.


16.


In Exercises 17 to 25, determine whether the graph of each equation is symmetric with respect to the a. *x*-axis, b. *y*-axis.

17. $y = 2x^2 - 5$ a. No b. Yes
18. $x = 3y^2 - 7$ a. Yes b. No
19. $y = x^3 + 2$ a. No b. No
20. $y = x^5 - 3x$ a. No b. No
21. $x^2 + y^2 = 9$ a. Yes b. Yes
22. $x^2 - y^2 = 10$ a. Yes b. Yes
23. $x^2 = y^4$ a. Yes b. Yes
24. $xy = 8$ a. No b. No
25. $|x| - |y| = 6$ a. Yes b. Yes

In Exercises 26 to 34, determine whether the graph of each equation is symmetric with respect to the origin.

26. $y = x + 1$ No
27. $y = 3x - 2$ No
28. $y = x^3 - x$ Yes
29. $y = -x^3$ Yes
30. $y = \dfrac{9}{x}$ Yes
31. $x^2 + y^2 = 10$ Yes
32. $x^2 - y^2 = 4$ Yes
33. $y = \dfrac{x}{|x|}$ Yes
34. $|y| = |x|$ Yes

In Exercises 35 to 48, determine whether the given function is an even function, an odd function, or neither.

35. $g(x) = x^2 - 7$ Even
36. $h(x) = x^2 + 1$ Even
37. $F(x) = x^5 + x^3$ Odd
38. $G(x) = 2x^5 - 10$ Neither
39. $H(x) = 3|x|$ Even
40. $T(x) = |x| + 2$ Even

Indicates Try It Exercises

41. $f(x) = 1$ Even

42. $k(x) = x^2 + 4x + 8$ Neither

43. $r(x) = \sqrt{x^2 + 4}$ Even

44. $u(x) = \sqrt{3 - x^2}$ Even

45. $s(x) = 16x^2$ Even

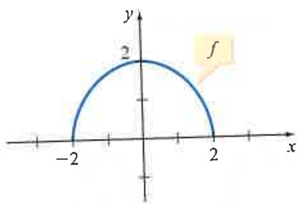
46. $v(x) = 16x^2 + x$ Neither

47. $w(x) = 4 + \sqrt[3]{x}$ Neither

48. $z(x) = \dfrac{x^3}{x^2 + 1}$ Odd

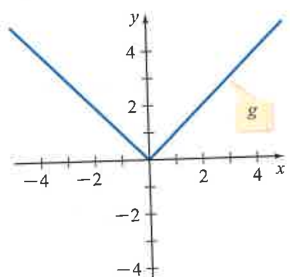
49. Use the graph of f to sketch the graph of

a. $y = f(x) + 3$ **b.** $y = f(x - 3)$



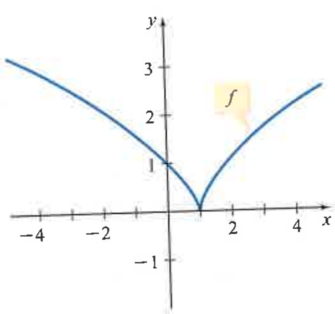
50. Use the graph of g to sketch the graph of

a. $y = g(x) - 2$ **b.** $y = g(x - 3)$



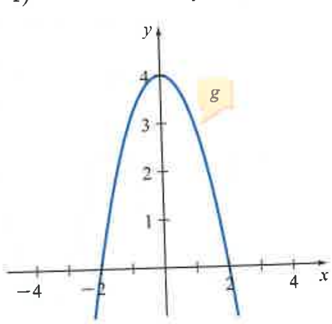
51. Use the graph of f to sketch the graph of

a. $y = f(x + 2)$ **b.** $y = f(x) + 2$



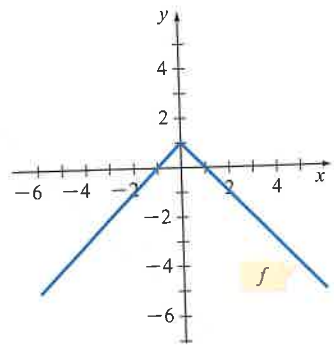
52. Use the graph of g to sketch the graph of

a. $y = g(x - 1)$ **b.** $y = g(x) - 1$



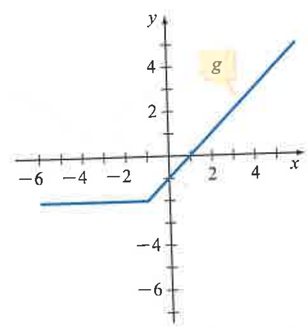
53. Use the graph of f to sketch a graph of

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



54. Use the graph of g to sketch a graph of

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



55. Let f be a function such that $f(-2) = 5$, $f(0) = -2$, and $f(1) = 0$. Give the coordinates of three points on the graph of

a. $y = f(x + 3)$
$(-5, 5), (-3, -2), (-2, 0)$

b. $y = f(x) + 1$
$(-2, 6), (0, -1), (1, 1)$

56. Let g be a function such that $g(-3) = -1$, $g(1) = -3$, and $g(4) = 2$. Give the coordinates of three points on the graph of

a. $y = g(x - 2)$
$(-1, -1), (3, -3), (6, 2)$

b. $y = g(x) - 2$
$(-3, -3), (1, -5), (4, 0)$

57. Let f be a function such that $f(-1) = 3$ and $f(2) = -4$. Give the coordinates of two points on the graph of

a. $y = f(-x)$
$(1, 3), (-2, -4)$

b. $y = -f(x)$
$(-1, -3), (2, 4)$

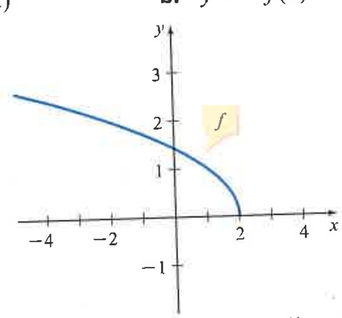
58. Let g be a function such that $g(4) = -5$ and $g(-3) = 2$. Give the coordinates of two points on the graph of

a. $y = -g(x)$
$(4, 5), (-3, -2)$

b. $y = g(-x)$
$(-4, -5), (3, 2)$

59. Use the graph of f to sketch the graph of

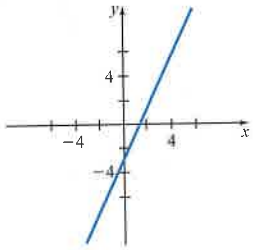
a. $y = f(-x)$ **b.** $y = -f(x)$



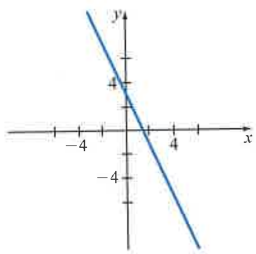
Enrichment Exercises

In Exercises 79 to 82, draw the graph that results from applying the operations to the given graph.

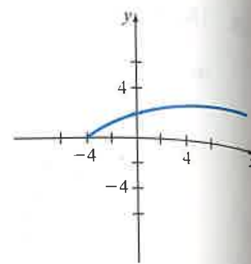
79. Reflect the graph about the y-axis and then about the origin.



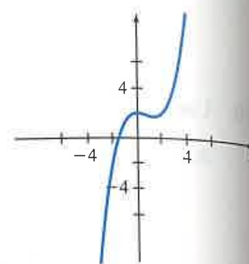
80. Reflect the graph about the origin and then about the y-axis.



81. Reflect the graph about the y-axis and then about the x-axis.



82. Reflect the graph about the x-axis and then about the origin.



SECTION 2.6

- Operations on Functions
- Difference Quotient
- Composition of Functions

Algebra of Functions

PREPARE FOR THIS SECTION

Prepare for this section by completing the following exercises. The answers can be found on page A13.

PS1. Subtract: $(2x^2 + 3x - 4) - (x^2 + 3x - 5)$ [P.3] $x^2 + 1$

PS2. Multiply: $(3x^2 - x + 2)(2x - 3)$ [P.3] $6x^3 - 11x^2 + 7x - 6$

In Exercises PS3 and PS4, find each of the following for $f(x) = 2x^2 - 5x + 2$.

PS3. $f(3a)$ [2.2] $18a^2 - 15a + 2$

PS4. $f(2 + h)$ [2.2] $2h^2 + 3h$

In Exercises PS5 and PS6, find the domain of each function.

PS5. $F(x) = \dfrac{x}{x - 1}$ [2.2] All real numbers except $x = 1$

PS6. $r(x) = \sqrt{2x - 8}$ [2.2] $[4, \infty)$

Operations on Functions

Functions can be defined in terms of other functions. For example, the function defined by $h(x) = x^2 + 8x$ is the sum of

$$f(x) = x^2 \qquad \text{and} \qquad g(x) = 8x$$

Thus, if we are given any two functions f and g, we can define the four new functions $f + g$, $f - g$, fg, and $\dfrac{f}{g}$ as follows.

Definitions of Operations on Functions

If f and g are functions with domains D_f and D_g, then we define the sum, difference, product, and quotient of f and g as

Sum	$(f + g)(x) = f(x) + g(x)$	Domain: $D_f \cap D_g$
Difference	$(f - g)(x) = f(x) - g(x)$	Domain: $D_f \cap D_g$