

19. $\phi(x) = \sqrt{\frac{x}{\pi - x}}$

20. $\phi(x) = \sqrt{\frac{x^2 - 2x}{x - 1}}$

21. $f(t) = \sqrt[3]{t - 1}$

22. $f(t) = \sqrt{t^2 + 1}$

23-50 ■ Find the domain and sketch the graph of the function.

23. $f(x) = 3 - 2x$

24. $f(x) = \frac{x + 3}{2}, -2 \leq x \leq 2$

25. $f(x) = x^2 + 2x - 1$

26. $f(x) = -x^2 + 6x - 7$

27. $g(x) = \sqrt{-x}$

28. $g(x) = \sqrt{6 - 2x}$

29. $h(x) = \sqrt{4 - x^2}$

30. $h(x) = \sqrt{x^2 - 4}$

31. $F(x) = \frac{1}{x}$

32. $F(x) = \frac{2}{x + 4}$

33. $G(x) = |x| + x$

34. $G(x) = |x| - x$

35. $H(x) = |2x|$

36. $H(x) = |2x - 3|$

37. $f(x) = x/|x|$

38. $f(x) = |x^2 - 1|$

39. $f(x) = \frac{x^2 - 1}{x - 1}$

40. $f(x) = \frac{x^2 + 5x + 6}{x + 2}$

41. $f(x) = \begin{cases} 0 & \text{if } x < 2 \\ 1 & \text{if } x \geq 2 \end{cases}$

42. $f(x) = \begin{cases} -1 & \text{if } x < -1 \\ 1 & \text{if } -1 \leq x \leq 1 \\ -1 & \text{if } x > 1 \end{cases}$

43. $f(x) = \begin{cases} x & \text{if } x \leq 0 \\ x + 1 & \text{if } x > 0 \end{cases}$

44. $f(x) = \begin{cases} 2x + 3 & \text{if } x < -1 \\ 3 - x & \text{if } x \geq -1 \end{cases}$

45. $f(x) = \begin{cases} -1 & \text{if } x < -1 \\ x & \text{if } -1 \leq x \leq 1 \\ 1 & \text{if } x > 1 \end{cases}$

46. $f(x) = \begin{cases} |x| & \text{if } |x| \leq 1 \\ 1 & \text{if } |x| > 1 \end{cases}$

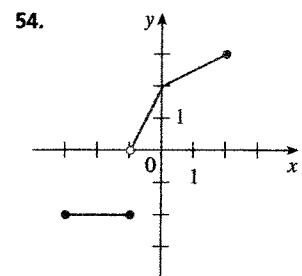
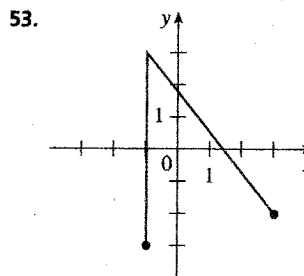
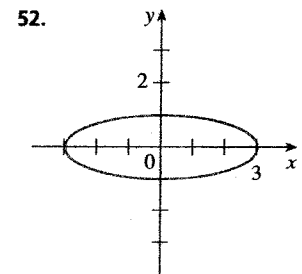
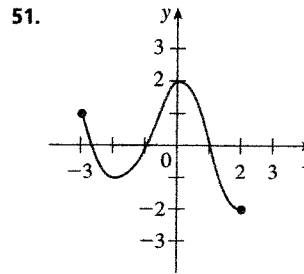
47. $f(x) = \begin{cases} x + 2 & \text{if } x \leq -1 \\ x^2 & \text{if } x > -1 \end{cases}$

48. $f(x) = \begin{cases} 1 - x^2 & \text{if } x \leq 2 \\ 2x - 7 & \text{if } x > 2 \end{cases}$

49. $f(x) = \begin{cases} -1 & \text{if } x \leq -1 \\ 3x + 2 & \text{if } |x| < 1 \\ 7 - 2x & \text{if } x \geq 1 \end{cases}$

50. $f(x) = \begin{cases} \sqrt{-x} & \text{if } x < 0 \\ x & \text{if } 0 \leq x \leq 2 \\ \sqrt{x - 2} & \text{if } x > 2 \end{cases}$

51-54 ■ State whether the curve is the graph of a function of x . If it is, state the domain and range of the function.



55-60 ■ Find a function whose graph is the given curve.

55. The line segment joining the points $(-2, 1)$ and $(4, -6)$

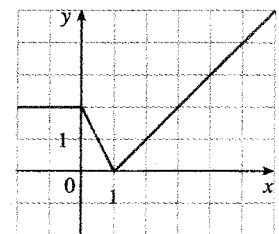
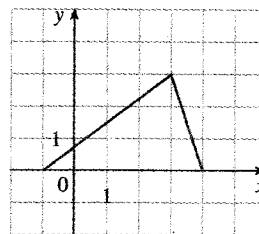
56. The line segment joining the points $(-3, -2)$ and $(6, 3)$

57. The bottom half of the parabola $x + (y - 1)^2 = 0$

58. The top half of the circle $(x - 1)^2 + y^2 = 1$

59.

60.



61-65 ■ Find a formula for the described function and state its domain.

61. A rectangle has perimeter 20 m. Express the area of the rectangle as a function of the length of one of its sides.

62. A rectangle has area 16 m². Express the perimeter of the rectangle as a function of the length of one of its sides.

63. Express the area of an equilateral triangle as a function of the length of a side.

64. Express the surface area of a cube as a function of its volume.

65. An open rectangular box with volume 2 m³ has a square base. Express the surface area of the box as a function of the length of a side of the base.

87–94 ■ Find the functions $f \circ g$, $g \circ f$, $f \circ f$, and $g \circ g$ and their domains.

87. $f(x) = 2x^2 - x$, $g(x) = 3x + 2$

88. $f(x) = \sqrt{x-1}$, $g(x) = x^2$

89. $f(x) = 1/x$, $g(x) = x^3 + 2x$

90. $f(x) = \frac{1}{x-1}$, $g(x) = \frac{x-1}{x+1}$

91. $f(x) = \sqrt[3]{x}$, $g(x) = 1 - \sqrt{x}$

92. $f(x) = \sqrt{x^2 - 1}$, $g(x) = \sqrt{1 - x}$

93. $f(x) = \frac{x+2}{2x+1}$, $g(x) = \frac{x}{x-2}$

94. $f(x) = \frac{1}{\sqrt{x}}$, $g(x) = x^2 - 4x$

95–98 ■ Find $f \circ g \circ h$.

95. $f(x) = x - 1$, $g(x) = \sqrt{x}$, $h(x) = x - 1$

96. $f(x) = \frac{1}{x}$, $g(x) = x^3$, $h(x) = x^2 + 2$

97. $f(x) = x^4 + 1$, $g(x) = x - 5$, $h(x) = \sqrt{x}$

98. $f(x) = \sqrt{x}$, $g(x) = \frac{x}{x-1}$, $h(x) = \sqrt[3]{x}$

99–102 ■ Express the function in the form $f \circ g$.

99. $F(x) = (x - 9)^5$ **100.** $F(x) = \sqrt{x} + 1$

101. $G(x) = \frac{x^2}{x^2 + 4}$ **102.** $G(x) = \frac{1}{x + 3}$

103–104 ■ Express the function in the form $f \circ g \circ h$.

103. $H(x) = \frac{1}{x^2 + 1}$ **104.** $H(x) = \sqrt[3]{\sqrt{x} - 1}$

105. A stone is dropped into a lake, creating a circular ripple that travels outward at a speed of 60 cm/s. Express the area of this circle as a function of time t (in seconds).

106. A spherical balloon is being inflated. If the radius of the balloon is increasing at a rate of 1 cm/s, express the volume of the balloon as a function of time t (in seconds).

107. If $f(x) = 3x + 5$ and $h(x) = 3x^2 + 3x + 2$, find a function g such that $f \circ g = h$.

108. If $f(x) = x + 4$ and $h(x) = 4x - 1$, find a function g such that $g \circ f = h$.

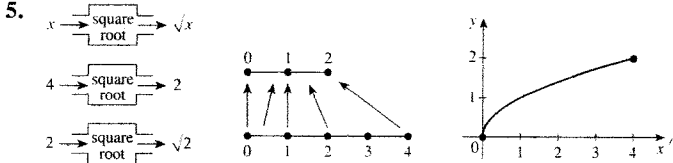
109. Let $f(x) = 1/x$ and $g(x) = x$. How does $f \circ f$ differ from g ?

[S11-05-09-10] Answers

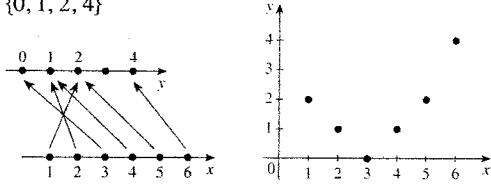
Exercises 1 ■ page 14

1. $-4, 10, 3\sqrt{2}, 5 + 7\sqrt{2}, 2x^2 - 3x - 4, 2x^2 + 7x + 1, 4x^2 + 6x - 8, 8x^2 + 6x - 4$

3. $-(h^2 + 3h + 2), x + h - x^2 - 2xh - h^2, 1 - 2x - h$



7. $\{0, 1, 2, 4\}$



9. $[-2, 3], [-6, 14]$ 11. $[\frac{5}{2}, \infty), [0, \infty)$

13. $\{x \mid |x| \leq 1\} = [-1, 1], [0, 1]$

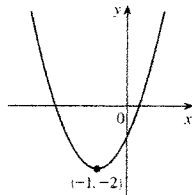
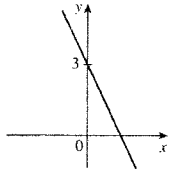
15. $\{x \mid x \neq \pm 1\} = (-\infty, -1) \cup (-1, 1) \cup (1, \infty)$

17. $\{x \mid x \leq 0 \text{ or } x \geq 6\} = (-\infty, 0] \cup [6, \infty)$

19. $[0, \pi)$ 21. $(-\infty, \infty)$

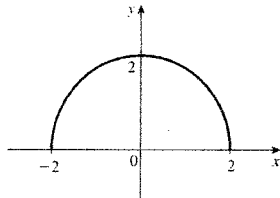
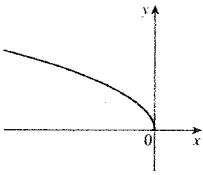
23. $(-\infty, \infty)$

25. $(-\infty, \infty)$



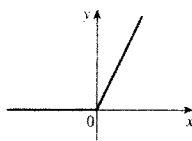
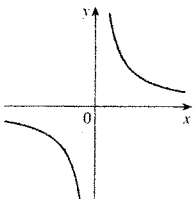
27. $(-\infty, 0]$

29. $[-2, 2]$

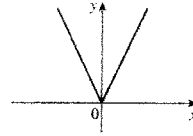


31. $\{x \mid x \neq 0\}$

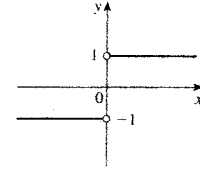
33. $(-\infty, \infty)$



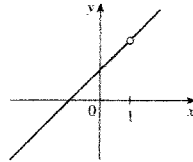
35. $(-\infty, \infty)$



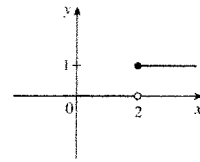
37. $(-\infty, 0) \cup (0, \infty)$



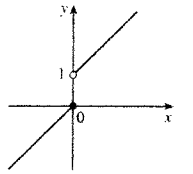
39. $(-\infty, 1) \cup (1, \infty)$



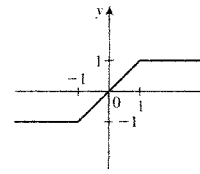
41. $(-\infty, \infty)$



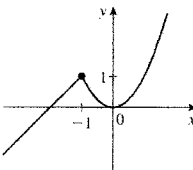
43. $(-\infty, \infty)$



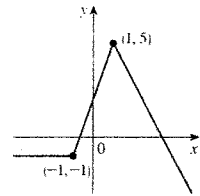
45. $(-\infty, \infty)$



47. $(-\infty, \infty)$



49. $(-\infty, \infty)$



51. Yes, $[-3, 2], [-2, 2]$ 53. No

55. $f(x) = -\frac{7}{6}x - \frac{4}{3}, -2 \leq x \leq 4$ 57. $f(x) = 1 - \sqrt{-x}$

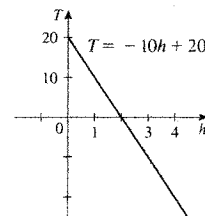
59. $f(x) = \begin{cases} x + 1 & \text{if } -1 \leq x \leq 2 \\ 6 - 1.5x & \text{if } 2 < x \leq 4 \end{cases}$

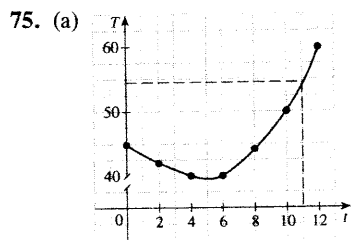
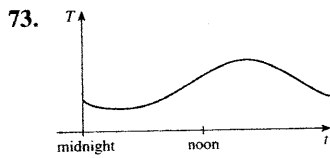
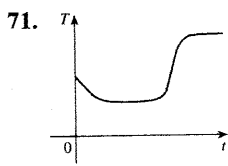
61. $A(L) = 10L - L^2, 0 < L < 10$

63. $A(x) = \sqrt{3}x^2/4, x > 0$ 65. $S(x) = x^2 + (8/x), x > 0$

67. $V(x) = 4x^3 - 64x^2 + 240x, 0 < x < 6$

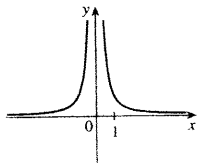
69. (a) $T(h) = 20 - 10h$
 (b) The rate of change of temperature with respect to height
 (c) -5°C





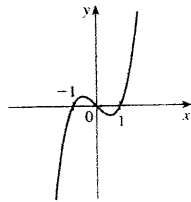
(b) 54°F

77. Even



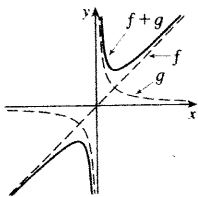
79. Neither

81. Odd



83. $(f + g)(x) = x^3 + 5x^2 - 1, (-\infty, \infty);$
 $(f - g)(x) = x^3 - x^2 + 1, (-\infty, \infty);$
 $(fg)(x) = 3x^5 + 6x^4 - x^3 - 2x^2, (-\infty, \infty);$
 $(f/g)(x) = (x^3 + 2x^2)/(3x^2 - 1), \{x \mid x \neq \pm 1/\sqrt{3}\}$

85.



87. $(f \circ g)(x) = 3(6x^2 + 7x + 2), (-\infty, \infty);$
 $(g \circ f)(x) = 6x^2 - 3x + 2, (-\infty, \infty);$
 $(f \circ f)(x) = 8x^4 - 8x^3 + x, (-\infty, \infty);$
 $(g \circ g)(x) = 9x + 8, (-\infty, \infty)$
89. $(f \circ g)(x) = 1/(x^3 + 2x), \{x \mid x \neq 0\};$
 $(g \circ f)(x) = (1/x^3) + (2/x), \{x \mid x \neq 0\};$
 $(f \circ f)(x) = x, \{x \mid x \neq 0\};$
 $(g \circ g)(x) = x^9 + 6x^7 + 12x^5 + 10x^3 + 4x, (-\infty, \infty)$
91. $(f \circ g)(x) = \sqrt[3]{1 - \sqrt{x}}, [0, \infty); (g \circ f)(x) = 1 - \sqrt[6]{x}, [0, \infty);$
 $(f \circ f)(x) = \sqrt[9]{x}, (-\infty, \infty); (g \circ g)(x) = 1 - \sqrt{1 - \sqrt{x}}, [0, 1]$
93. $(f \circ g)(x) = (3x - 4)/(3x - 2), \{x \mid x \neq 2, \frac{2}{3}\};$
 $(g \circ f)(x) = -(x + 2)/(3x), \{x \mid x \neq 0, -\frac{1}{3}\};$
 $(f \circ f)(x) = (5x + 4)/(4x + 5), \{x \mid x \neq -\frac{1}{2}, -\frac{5}{4}\};$
 $(g \circ g)(x) = x/(4 - x), \{x \mid x \neq 2, 4\}$

95. $(f \circ g \circ h)(x) = \sqrt{x - 1} - 1$

97. $(f \circ g \circ h)(x) = (\sqrt{x} - 5)^4 + 1$

99. $g(x) = x - 9, f(x) = x^5$

101. $g(x) = x^2, f(x) = x/(x + 4)$

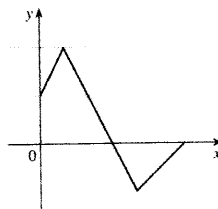
103. $h(x) = x^2, g(x) = x + 1, f(x) = 1/x$

105. $A = 3600\pi t^2$ 107. $g(x) = x^2 + x - 1$
109. $f \circ f$ has domain $\{x \mid x \neq 0\}$

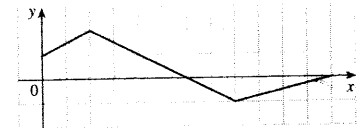
Exercises 2 ■ page 25

1. (a) Root (b) Algebraic (c) Polynomial (degree 9)
(d) Rational (e) Trigonometric (f) Logarithmic

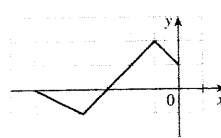
3. (a)



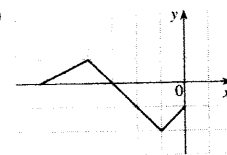
(b)



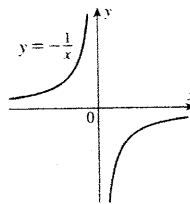
(c)



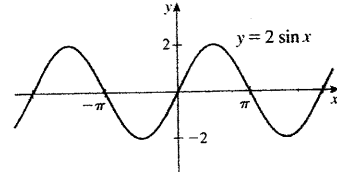
(d)



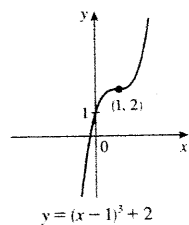
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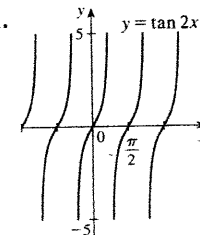
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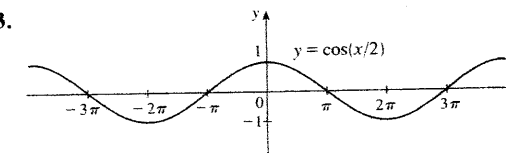
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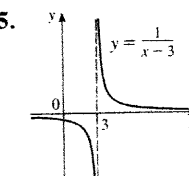
11.



13.



15.



17.

