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

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

**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.** $f(x) = \dfrac{x + 3}{2}, \quad -2 \leqslant x \leqslant 2$

**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.** $F(x) = \dfrac{1}{x}$

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

**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.** $f(x) = \dfrac{x^2 - 1}{x - 1}$

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

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

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

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

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

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

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

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

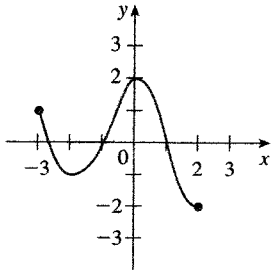
**48.** $f(x) = \begin{cases} 1 - x^2 & \text{if } x \leqslant 2 \\ 2x - 7 & \text{if } x > 2 \end{cases}$

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

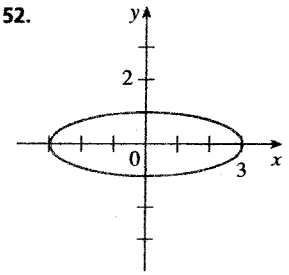
**50.** $f(x) = \begin{cases} \sqrt{-x} & \text{if } x < 0 \\ x & \text{if } 0 \leqslant x \leqslant 2 \\ \sqrt{x - 2} & \text{if } x > 2 \end{cases}$

**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.

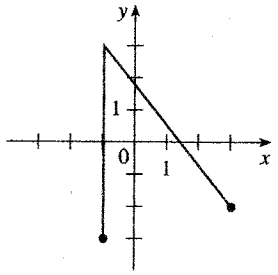
**51.**



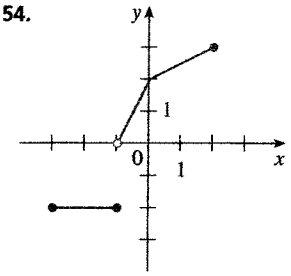

**52.**




**53.**




**54.**




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

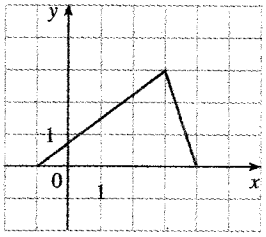
**55.** The line segment joining the points $(-2, 1)$ and $(4, -6)$

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

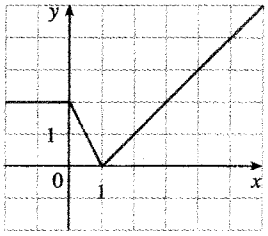
**57.** The bottom half of the parabola $x + (y - 1)^2 = 0$

**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 m$^2$. 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 m$^3$ 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.** $f(x) = 2x^2 - x, \quad g(x) = 3x + 2$

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

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

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

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

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

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

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

**95–98** ■ Find $f \circ g \circ h$.

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

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

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

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

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

**99.** $F(x) = (x - 9)^5$

**100.** $F(x) = \sqrt{x} + 1$

**101.** $G(x) = \dfrac{x^2}{x^2 + 4}$

**102.** $G(x) = \dfrac{1}{x + 3}$

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

**103.** $H(x) = \dfrac{1}{x^2 + 1}$

**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

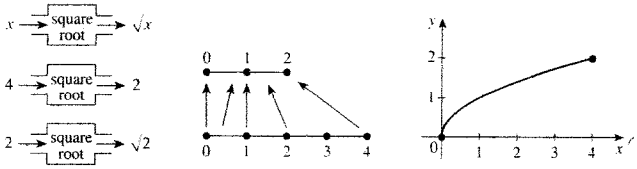
## REVIEW AND PREVIEW

### Exercises 1 ■ page 14

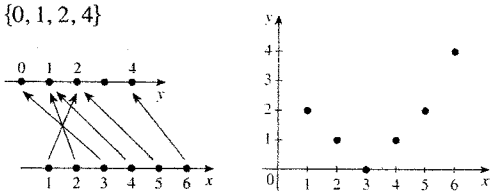
**1.** $-4,\ 10,\ 3\sqrt{2},\ 5+7\sqrt{2},\ 2x^2-3x-4,\ 2x^2+7x+1,\ 4x^2+6x-8,\ 8x^2+6x-4$

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

**5.**




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




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

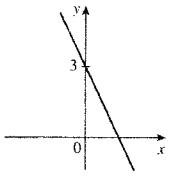
**13.** $\{x \mid |x| \leq 1\} = [-1, 1],\ [0, 1]$

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

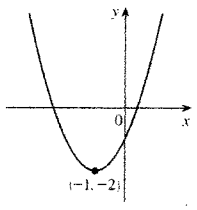
**17.** $\{x \mid x \leq 0 \text{ or } x \geq 6\} = (-\infty, 0] \cup [6, \infty)$

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

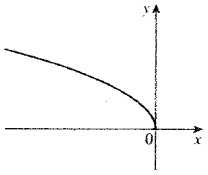
**23.** $(-\infty, \infty)$



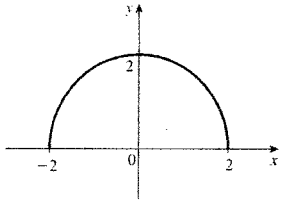

**25.** $(-\infty, \infty)$



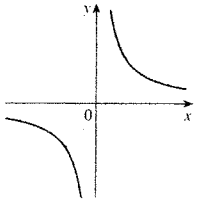

**27.** $(-\infty, 0]$



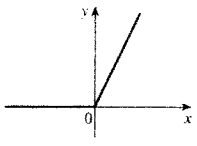

**29.** $[-2, 2]$



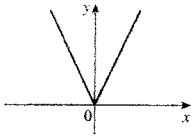

**31.** $\{x \mid x \neq 0\}$



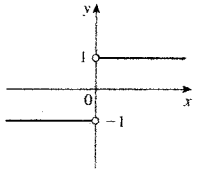

**33.** $(-\infty, \infty)$



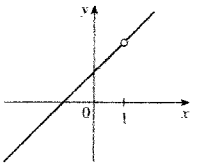

**35.** $(-\infty, \infty)$



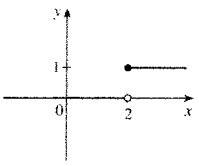

**37.** $(-\infty, 0) \cup (0, \infty)$



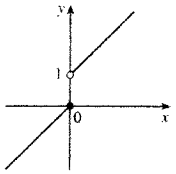

**39.** $(-\infty, 1) \cup (1, \infty)$



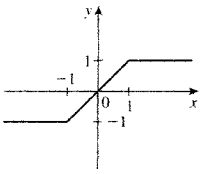

**41.** $(-\infty, \infty)$



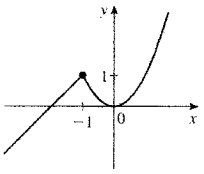

**43.** $(-\infty, \infty)$



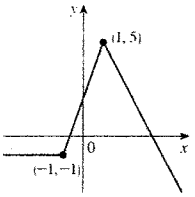

**45.** $(-\infty, \infty)$




**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.** $f(x) = 1 - \sqrt{-x}$

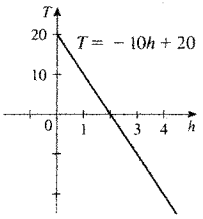
**59.** $f(x) = \begin{cases} x + 1 & \text{if } -1 \leq x \leq 2 \\ 6 - 1.5x & \text{if } 2 < x \leq 4 \end{cases}$

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

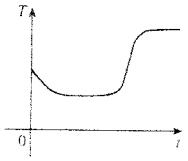
**63.** $A(x) = \sqrt{3}\,x^2/4,\ x > 0$ **65.** $S(x) = x^2 + (8/x),\ x > 0$

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

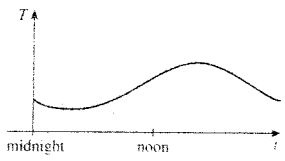
**69.** (a) $T(h) = 20 - 10h$
(b) The rate of change of temperature with respect to height
(c) $-5\,^\circ\text{C}$



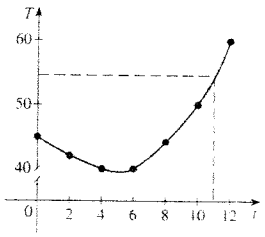
**71.**




**73.**

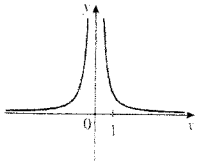



**75.** (a)



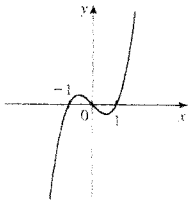

(b) 54 °F

**77.** Even



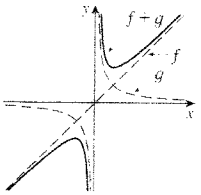

**79.** Neither

**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.** $(f \circ g)(x) = (3x - 4)/(3x - 2)$, $\{x \mid x \neq 2, \frac{2}{3}\}$;
$(g \circ f)(x) = -(x + 2)/(3x)$, $\{x \mid x \neq 0, -\frac{1}{2}\}$;
$(f \circ f)(x) = (5x + 4)/(4x + 5)$, $\{x \mid x \neq -\frac{1}{5}, -\frac{5}{4}\}$;
$(g \circ g)(x) = x/(4 - x)$, $\{x \mid x \neq 2, 4\}$

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

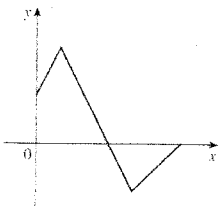
**105.** $A = 3600\pi t^2$ **107.** $g(x) = x^2 + x - 1$

**109.** $f \circ f$ has domain $\{x \mid x \neq 0\}$

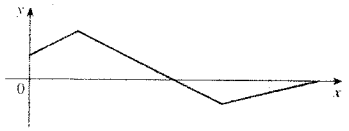
## Exercises 2 ■ page 25

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

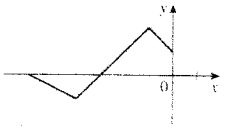
**3.** (a)



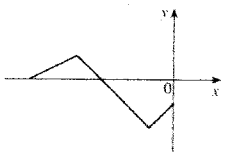

(b)



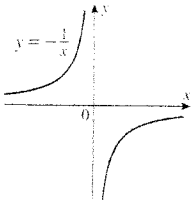

(c)




(d)




**5.**

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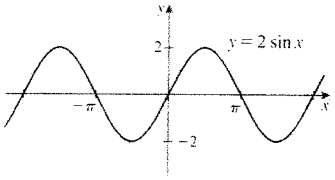


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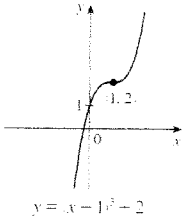


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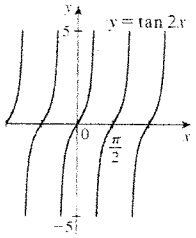


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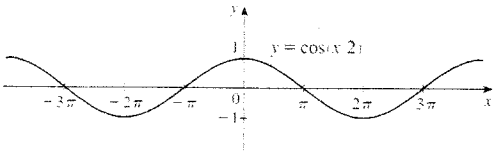


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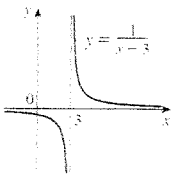


**17.**