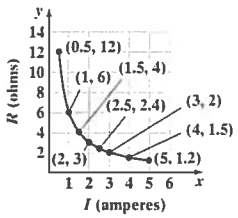
39. a.

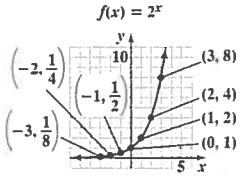


b. Current varies inversely as resistance. **c.** $R = \frac{6}{I}$

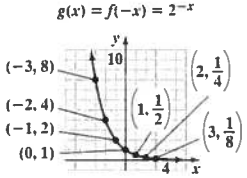
49. does not make sense **50.** does not make sense **51.** makes sense **52.** makes sense **53.** The destructive power is four times as much.

54. The illumination is $\frac{1}{4}$ as much. **55.** Reduce the resistance by a factor of $\frac{1}{3}$.

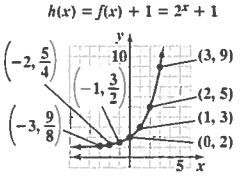
58.



59.

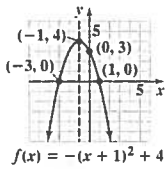


60.



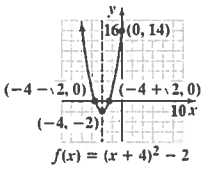
Chapter 3 Review Exercises

1.



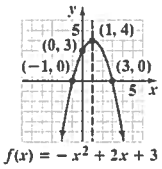
axis of symmetry; $x = -1$
domain: $(-\infty, \infty)$; range: $(-\infty, 4]$

2.



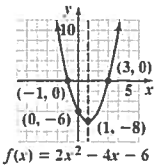
axis of symmetry: $x = -4$
domain: $(-\infty, \infty)$; range: $[-2, \infty)$

3.



axis of symmetry: $x = 1$
domain: $(-\infty, \infty)$; range: $(-\infty, 4]$

4.

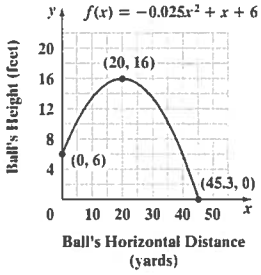


axis of symmetry: $x = 1$
domain: $(-\infty, \infty)$; range: $[-8, \infty)$

5. a. maximum is -57 at $x = 7$ **b.** domain: $(-\infty, \infty)$; range: $(-\infty, -57]$

6. a. minimum is 685 at $x = -3$ **b.** domain: $(-\infty, \infty)$; range: $[685, \infty)$

7. a. 16 ft; 20 yd **b.** 6 ft **c.** 45.3 yd **d.**



8. 250 yd by 500 yd; 125,000 sq yard **9.** -7 and 7; -49

10. c **11.** b **12.** a **13.** d **14.** No; the graph falls to the right, so eventually there would be a negative number of thefts, which is not possible.

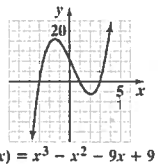
15. The graph falls to the right; eventually the elk population will be extinct.

16. $x = 1$, multiplicity 1, crosses; $x = -2$, multiplicity 2, touches; $x = -5$, multiplicity 3, crosses

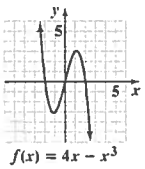
17. $x = -5$, multiplicity 1, crosses; $x = 5$, multiplicity 2, touches

18. $f(1)$ is negative and $f(2)$ is positive, so by the Intermediate Value Theorem, f has a real zero between 1 and 2.

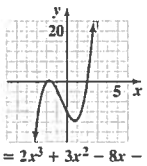
19. a. The graph falls to the left and rises to the right.
b. no symmetry
c.



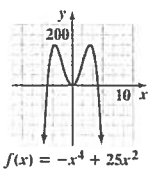
20. a. The graph rises to the left and falls to the right.
b. origin symmetry
c.



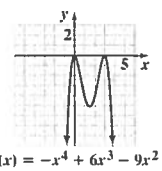
21. a. The graph falls to the left and rises to the right.
b. no symmetry
c.



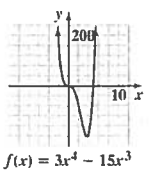
22. a. The graph falls to the left and to the right.
b. y-axis symmetry
c.



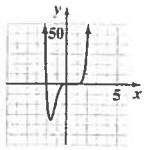
23. a. The graph falls to the left and to the right.
b. no symmetry
c.



24. a. The graph rises to the left and to the right.
b. no symmetry
c.

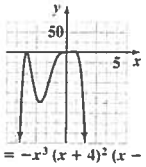


25.



$f(x) = 2x^2(x-1)^3(x+2)$

26.



$f(x) = -x^3(x+4)^2(x-1)$

27. $4x^2 - 7x + 5 - \dfrac{4}{x+1}$

28. $2x^2 - 4x + 1 - \dfrac{10}{5x-3}$

29. $2x^2 + 3x - 1$ **30.** $3x^3 - 4x^2 + 7$

31. $3x^3 + 6x^2 + 10x + 10 + \dfrac{20}{x-2}$ **32.** -5697

33. $2, \frac{1}{2}, -3$ **34.** $\{4, -2 \pm \sqrt{5}\}$ **35.** $\pm 1, \pm 5$ **36.** $\pm 1, \pm 2, \pm 4, \pm 8, \pm\frac{8}{3}, \pm\frac{4}{3}, \pm\frac{2}{3}, \pm\frac{1}{3}$ **37.** 2 or 0 positive real zeros; no negative real zeros

38. 3 or 1 positive real zeros; 2 or 0 negative real zeros **39.** No sign variations exist for either $f(x)$ or $f(-x)$, so no real roots exist.

40. **a.** $\pm 1, \pm 2, \pm 4$ **b.** 1 positive real zero; 2 or no negative real zeros **c.** -2 or 1 **d.** $-2, 1$

41. **a.** $\pm 1, \pm\frac{1}{2}, \pm\frac{1}{3}, \pm\frac{1}{6}$ **b.** 2 or 0 positive real zeros; 1 negative real zero **c.** $-1, \frac{1}{3}$, or $\frac{1}{2}$ **d.** $-1, \frac{1}{3}, \frac{1}{2}$

42. **a.** $\pm 1, \pm 3, \pm 5, \pm 15, \pm\frac{1}{2}, \pm\frac{1}{4}, \pm\frac{1}{8}, \pm\frac{3}{2}, \pm\frac{3}{4}, \pm\frac{3}{8}, \pm\frac{5}{2}, \pm\frac{5}{4}, \pm\frac{5}{8}, \pm\frac{15}{2}, \pm\frac{15}{4}, \pm\frac{15}{8}$ **b.** 3 or 1 positive real solutions; no negative real solutions **c.** $\frac{1}{2}, \frac{3}{2}$, or $\frac{5}{2}$ **d.** $\left\{\frac{1}{2}, \frac{3}{2}, \frac{5}{2}\right\}$ **43.** **a.** $\pm 1, \pm\frac{1}{2}$ **b.** 2 or 0 positive real solutions; 1 negative solution **c.** $\frac{1}{2}$ **d.** $\left\{\frac{1}{2}, \frac{-5-\sqrt{29}}{2}, \frac{-5+\sqrt{29}}{2}\right\}$

44. **a.** $\pm 1, \pm 2, \pm 3, \pm 6$ **b.** 2 or zero positive real solutions; 2 or zero negative real solutions **c.** $-2, -1, 1$, or 3 **d.** $\{-2, -1, 1, 3\}$

45. **a.** $\pm 1, \pm 2, \pm\frac{1}{2}, \pm\frac{1}{4}$ **b.** 1 positive real root; 1 negative real root **c.** $-\frac{1}{2}$ or $\frac{1}{2}$ **d.** $\left\{-\frac{1}{2}, \frac{1}{2}, i\sqrt{2}, -i\sqrt{2}\right\}$

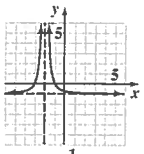
46. **a.** $\pm 1, \pm 2, \pm 4, \pm\frac{1}{2}$ **b.** 2 or no positive zeros; 2 or no negative zeros **c.** $-2, -1, \frac{1}{2}$, or 2 **d.** $\left\{-2, -1, \frac{1}{2}, 2\right\}$

47. $f(x) = x^3 - 6x^2 + 21x - 26$ **48.** $f(x) = 2x^4 + 12x^3 + 20x^2 + 12x + 18$ **49.** $-2, \frac{1}{2}, \pm i$; $f(x) = (x-i)(x+i)(x+2)(2x-1)$

50. $-1, 4$; $g(x) = (x+1)^2(x-4)^2$ **51.** 4 real zeros, one with multiplicity two **52.** 3 real zeros; 2 nonreal complex zeros

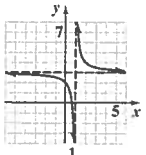
53. 2 real zeros, one with multiplicity two; 2 nonreal complex zeros **54.** 1 real zero; 4 nonreal complex zeros

55.



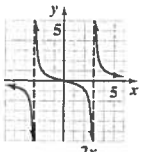
$g(x) = \dfrac{1}{(x+2)^2} - 1$

56.



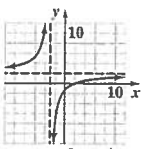
$h(x) = \dfrac{1}{x-1} + 3$

57. Vertical asymptote: $x = 3$ and $x = -3$
horizontal asymptote: $y = 0$



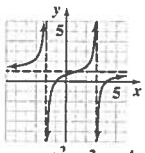
$f(x) = \dfrac{2x}{x^2 - 9}$

58. Vertical asymptote: $x = -3$
horizontal asymptote: $y = 2$



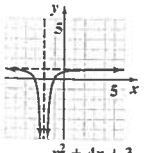
$f(x) = \dfrac{2x-4}{x+3}$

59. Vertical asymptotes: $x = 3, -2$
horizontal asymptote: $y = 1$



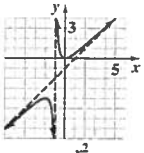
$h(x) = \dfrac{x^2 - 3x - 4}{x^2 - x - 6}$

60. Vertical asymptote: $x = -2$
horizontal asymptote: $y = 1$



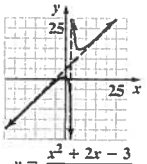
$r(x) = \dfrac{x^2 + 4x + 3}{(x+2)^2}$

61. Vertical asymptote: $x = -1$
no horizontal asymptote
slant asymptote: $y = x - 1$



$y = \dfrac{x^2}{x+1}$

62. Vertical asymptote: $x = 3$
no horizontal asymptote
slant asymptote: $y = x + 5$

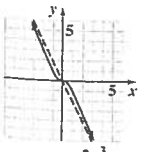


$y = \dfrac{x^2 + 2x - 3}{x - 3}$

63. No vertical asymptote

no horizontal asymptote

slant asymptote: $y = -2x$

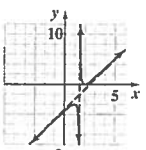


$f(x) = \dfrac{-2x^3}{x^2 + 1}$

64. Vertical asymptote: $x = \dfrac{3}{2}$

no horizontal asymptote

slant asymptote: $y = 2x - 5$



$g(x) = \dfrac{4x^2 - 16x + 16}{2x - 3}$

65. **a.** $C(x) = 25x + 50{,}000$

b. $\overline{C}(x) = \dfrac{25x + 50{,}000}{x}$

c. $\overline{C}(50) = 1025$, when 50 calculators are manufactured, it costs \$1025 to manufacture each; $\overline{C}(100) = 525$, when 100 calculators are manufactured, it costs \$525 to manufacture each; $\overline{C}(1000) = 75$, when 1000 calculators are manufactured, it costs \$75 to manufacture each; $\overline{C}(100{,}000) = 25.5$, when 100,000 calculators are manufactured, it costs \$25.50 to manufacture each.

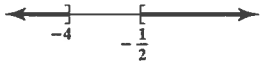
d. $y = 25$; costs will approach \$25.

66. $y = 3000$; The number of fish in the pond approaches 3000.
67. $y = 0$; As the number of years of education increases the percentage rate of unemployment approaches zero.

68. a. $P(x) = 3.06x + 235$ **b.** $R(x) = \dfrac{1.58x + 114.4}{3.06x + 235}$ **c.** $y = 0.52$; Over time the percentage of men in the U.S. population will approach 52%.

69. $\left(-3, \frac{1}{2}\right)$

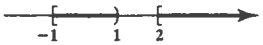
70. $(-\infty, -4] \cup \left[-\frac{1}{2}, \infty\right)$



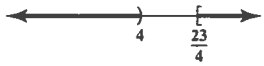
71. $(-3, 0) \cup (1, \infty)$

72. $(-\infty, -2) \cup (6, \infty)$

73. $[-1, 1) \cup [2, \infty)$



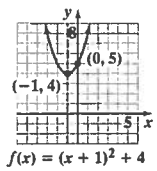
74. $(-\infty, 4) \cup \left[\frac{23}{4}, \infty\right)$



75. a. 261 ft; overestimates by 1 ft **b.** speeds exceeding 40 miles per hour **76.** from 1 to 2 sec **77.** 134.4 cm^3 **78.** 1600 ft
79. 440 vibrations per second **80.** 112 decibels **81.** 16 hr **82.** 800 ft^3 **83. a.** $L = \dfrac{1890}{R}$ **b.** an approximate model **c.** 70 yr

Chapter 3 Test

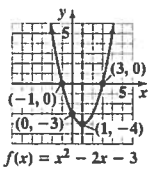
1.



$f(x) = (x + 1)^2 + 4$

axis of symmetry: $x = -1$
domain: $(-\infty, \infty)$; range: $[4, \infty)$

2.

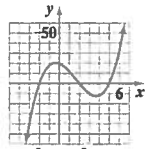


$f(x) = x^2 - 2x - 3$

axis of symmetry: $x = 1$
domain: $(-\infty, \infty)$; range: $[-4, \infty)$

3. a. maximum of 2 at $x = 3$;
b. domain: $(-\infty, \infty)$; range: $(-\infty, 2]$
4. 23 computers;
maximum daily profit = \$16,900
5. 7 and 7; 49

6. a. 5, 2, −2
b.



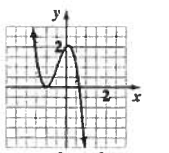
$f(x) = x^3 - 5x^2 - 4x + 20$

7. Since the degree of the polynomial is odd and the leading coefficient is positive, the graph of f should fall to the left and rise to the right. The x-intercepts should be -1, 0, and 1.

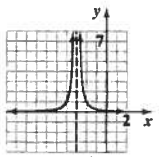
8. a. 2 **b.** $\frac{1}{2}, \frac{2}{3}$ **9.** $\pm 1, \pm 2, \pm 3, \pm 6, \pm\frac{1}{2}, \pm\frac{3}{2}$
10. 3 or 1 positive real zeros; no negative real zeros.

11. $\{-3, -3 - \sqrt{11}, -3 + \sqrt{11}\}$ **12. a.** $\pm 1, \pm 3, \pm 5, \pm 15, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{5}{2}, \pm\frac{15}{2}$ **b.** $-\sqrt{5}, -1, \frac{3}{2}$, and $\sqrt{5}$ **13.** $(x - 1)(x + 2)^2$

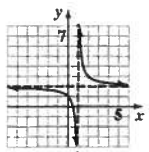
14. $f(x) = 2x^4 - 2$ **15.** -1 and $\frac{2}{3}$ **16.** $(-\infty, -3) \cup (-3, \infty)$ **17.** $(-\infty, 1) \cup (1, \infty)$



$f(x) = -3x^3 - 4x^2 + x + 2$

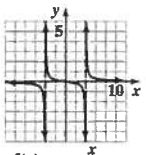


$f(x) = \dfrac{1}{(x + 3)^2}$

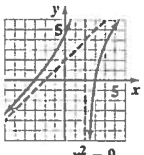


$f(x) = \dfrac{1}{x - 1} + 2$

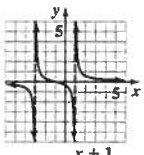
18. domain: $\{x | x \neq 4, x \neq -4\}$ **19.** domain: $\{x | x \neq 2\}$ **20.** domain: $\{x | x \neq -3, x \neq 1\}$ **21.** domain: all real numbers



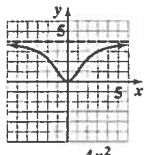
$f(x) = \dfrac{x}{x^2 - 16}$



$f(x) = \dfrac{x^2 - 9}{x - 2}$



$f(x) = \dfrac{x + 1}{x^2 + 2x - 3}$

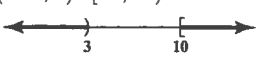


$f(x) = \dfrac{4x^2}{x^2 + 3}$

22. a. $\overline{C}(x) = \dfrac{300{,}000 + 10x}{x}$ **b.** $y = 10$; As the number of satellite radio players increases, the average cost approaches \$10.

23. $(-3, 4)$

24. $(-\infty, 3) \cup [10, \infty)$



25. 45 foot-candles

Cumulative Review Exercises (Chapters 1–3)

1. domain: $(-2, 2)$; range: $[0, \infty)$ **2.** -1 and 1, both of multiplicity 2 **3.** 0 **4.** 3 **5.** $x \to -2^+$; $x \to 2^-$