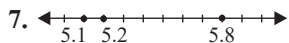
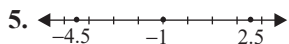


# Answer Key

## Chapter 0: Fundamental Concepts of Algebra

### 0.1 EXERCISES

1. a.  $19, 2^5$     b.  $19, \frac{0}{15}, 2^5$   
 c.  $19, \frac{0}{15}, 2^5, -33$   
 d.  $19, -4.3, \frac{0}{15}, 2^5, -33$   
 e.  $-\sqrt{3}$     f. all except  $\frac{15}{0}$   
 g.  $\frac{15}{0}$
3. a.  $|-16|, \frac{12}{3}, \sqrt{4}$   
 b.  $|-16|, \frac{12}{3}, 0, \sqrt{4}$   
 c.  $|-16|, \frac{12}{3}, 0, \sqrt{4}$   
 d. all    e. none    f. all    g. none



9.  $<, \leq$     11.  $<, \leq$   
 13.  $<, \leq$     15.  $>, \geq$   
 17.  $>, \geq$     19.  $2a + b > c$   
 21.  $9 \geq 7$     23.  $x + 5 < 3$   
 25.  $9 \geq 8$
27.  $\{3n | n \text{ is an integer and } -2 \leq n \leq 3\}$   
 29.  $\{n | n \text{ is a prime}\}$   
 31.  $\left\{\frac{1}{n} | n \text{ is an odd integer}\right\}$   
 33.  $(-\infty, 15)$     35.  $(2.5, 3.7]$   
 37.  $(-\infty, 4)$     39.  $\left(-\frac{1}{2}, \frac{2}{5}\right)$   
 41.  $[0, \infty)$
- 43.
- 45.
- 47.
49. 4    51.  $\sqrt{5} - \sqrt{3}$   
 53. -15    55. 1

57. -1    59. -12  
 61. 8    63. 6  
 65. 11  
 67. JR > Freddie > Sarah > Aubrey > Elizabeth  
 69. If age =  $x$ ,  
 $\{x | x < 2\} = [0, 2) \rightarrow \text{free};$   
 $\{x | 2 \leq x < 12\} = [2, 12) \rightarrow \$3;$   
 $\{x | 12 \leq x < 65\} = [12, 65) \rightarrow \$7;$   
 $\{x | x \geq 65\} = [65, \infty) \rightarrow \$5$   
 71. No, because all natural numbers can be expressed as fractions.

### 0.2 EXERCISES

1.  $3x^2y^3, -2\sqrt{x+y}, 7z$   
 3.  $-2, \sqrt{x+y}$   
 5. 1, 8.5, -14  
 7.  $\frac{-5x}{2yz}, -8x^5y^3, 6.9z$   
 9.  $\frac{-5}{2}, \frac{1}{y}, \frac{1}{z}, x$     11. 20  
 13. 8    15.  $-\frac{\sqrt{2}}{36} + 2$   
 17. 4    19.  $58 + 6\pi$   
 21.  $\frac{-1}{3}$   
 23. Commutative    25. Associative  
 27. Associative    29. Distributive  
 31. Commutative  
 33. Multiplicative cancellation;  $\frac{1}{5}$   
 35. Additive cancellation;  $x$   
 37. Zero-Factor Property  
 39. Multiplicative cancellation; 6  
 41. Multiplicative cancellation;  $\frac{1}{3}$   
 43.  $\frac{11}{2}$     45. -10  
 47. 1    49. 70

51.  $\frac{103}{6}$     53.  $\frac{-144}{5}$   
 55.  $\frac{37}{2}$     57. 23.66  
 59. 1.64  
 61.  $-\frac{1}{5}(\sqrt{3(3+7)}-5)^3$   
 63.  $\left(\frac{\sqrt[3]{x-4}}{2}\right)^2$     65.  $(-5, 4]$   
 67.  $[3, 4]$     69.  $[-\pi, 21)$   
 71.  $(3, 9]$     73.  $\mathbb{Z}$   
 75.  $\mathbb{Z}$     77. \$66  
 79. \$102  
 81. 2.19 square meters  
 83. It is the same number you began with. Explanations may vary.  
 85. Answers may vary. (Ex: Please Excuse My Dear Aunt Sally.)

### 0.3 EXERCISES

1. 16    3. -9  
 5. 81    7. 64  
 9. 1    11.  $\frac{1}{7}$   
 13.  $x^3$     15.  $27s^{10}$   
 17. -2    19.  $x^3$   
 21.  $121x^7$     23.  $x$   
 25.  $\frac{1}{x^2}$     27.  $x^3y^3$   
 29.  $\frac{16}{s^3}$     31.  $-\frac{y^5}{3x^2}$   
 33.  $\frac{1}{3y^2z}$     35.  $27x^2y^4$   
 37. 1    39.  $\frac{c^2}{9a^7b^3}$   
 41.  $\frac{81y^3z^2}{2x^3}$     43.  $\frac{64a^6}{b^{15}}$   
 45.  $27x^9$     47.  $\frac{1}{5z^6 - 81x^{12}}$

**0.4 EXERCISES**

- 1. -3
- 5. -2
- 9. Not real
- 13.  $-\frac{1}{2}$
- 17.  $\frac{2}{5}$
- 21.  $\frac{x^2|z|}{2}$
- 25.  $\frac{ab^4}{3c^2}$
- 29.  $\frac{y^6z^5}{2x^7}$
- 33.  $-\sqrt{2}-\sqrt{5}$
- 37.  $\frac{x+\sqrt{2x}}{x-2}$
- 39.  $\frac{x+2\sqrt{xy}+y}{x-y}$
- 41.  $\frac{y-2\sqrt{y}}{y-4}$
- 45.  $\frac{1}{18-6\sqrt{y}}$
- 49.  $\frac{6-y}{6+y-2\sqrt{6y}}$
- 51.  $bh+bl+hl+l\sqrt{b^2+h^2}$
- 3. Not real
- 7. -5
- 11.  $-\frac{3}{5}$
- 15. 2
- 19.  $3|x|$
- 23.  $x^2y^7z^3$
- 27.  $\frac{|x^3|y^2}{2}$
- 31.  $\frac{\sqrt[3]{36x^2y^2}}{3y^2}$
- 35.  $\sqrt{6}+\sqrt{3}$
- 43.  $\frac{1}{\sqrt{5}+3}$
- 47.  $\frac{1}{\sqrt{13}-\sqrt{t}}$

53. Because a positive number squared is positive and a negative number squared is positive.

**0.5 EXERCISES**

- 1.  $3x\sqrt[3]{2x}$
- 5. 0
- 9. 0
- 13. 27
- 17.  $\frac{x^{\frac{4}{5}}}{y^{\frac{5}{3}}}$
- 21.  $y\sqrt[3]{y^2}$
- 25.  $a^{\frac{15}{4}}$
- 29.  $6^{\frac{1}{3}}$
- 33.  $\sqrt[4]{|y|}$
- 37.  $\sqrt[6]{16,807}$
- 39.  $3a^2\sqrt{3}; 3.326 \text{ cm}^2$
- 41. Because a root is the same as a fractional exponent.
- 3. Not possible
- 7.  $4z\sqrt[3]{2z}$
- 11.  $(3x^2-4)^2$
- 15.  $n^2$
- 19.  $\frac{1}{125}$
- 23.  $(ax^2+by)^{\frac{1}{12}}$
- 27.  $x^{\frac{1}{4}}$
- 31.  $\sqrt[4]{125}$
- 35.  $x^3$

- 9.  $3a^2-8ab$
- 11.  $-7x^2-5xy+5y^2$
- 13.  $6x^4+10x^3-2x^2$
- 15.  $12xy$
- 17.  $x^4, x^2y, y^2$
- 19.  $14x^2-9x-18$
- 21.  $12x^2-25x+12$
- 23.  $16x^2-24x+9$
- 25.  $9x^2+12xy+4y^2$
- 27.  $36x^2-y^2$
- 29.  $2x^3+6x^2-8x$
- 31.  $x^3+27$
- 33.  $x^3+8y^3$
- 35.  $-7x+9$
- 37.  $7t+7$
- 39.  $4x^2-x$
- 41.  $3y, 4, 6$
- 43.  $(s-7)(s+2)$
- 45.  $(x+13)(x-2)$
- 47.  $4b(b-4)(b+4)$
- 49.  $3(3a-2)(3a+2)$
- 51.  $(x-1)(x+1)(x^2+x+1)(x^2-x+1)$
- 53.  $(5x^4-4)(5x^4+4)$
- 55.  $2(t+2y)(t^2-2ty+4y^2)$
- 57.  $(s+1)(s-1)(s^2+1)$
- 59.  $100x(y+1)^2$
- 61. Answers will vary

**0.6 EXERCISES**

- 1.  $2x^2+x+5$
- 5.  $x^2+8x+2$
- 7.  $4x^2+3x+11$
- 3.  $5a^2+14a-2$

**Chapter 1: Equations and Inequalities in One Variable**

**1.1 EXERCISES**

- 1.  $x=-3$
- 5.  $x=2$
- 9.  $y=-1$
- 13.  $x=-0.12$
- 17.  $x=0$
- 21.  $x=-2$
- 25.  $n=6$
- 29.  $x=0$
- 33.  $x=-\frac{1}{8}$
- 37.  $x=-\frac{21}{5}$
- 3.  $x=2$
- 7.  $x=2$
- 11.  $t=-1$
- 15.  $x=4$
- 19.  $y=0$
- 23.  $y=-6$
- 27.  $n=8$
- 31.  $x=-7$
- 35.  $x=-\frac{13}{2}$
- 39.  $x=-\frac{8}{15}$
- 41.  $y=\frac{28}{5}$
- 45.  $y=\frac{7}{5}$
- 49.  $x=-44$
- 53.  $x=-4$
- 57.  $x=1.5$
- 61.  $x=-5$
- 65.  $y=6$
- 69.  $n=0$
- 73.  $z=-1$
- 77.  $x=-3$
- 43.  $x=2$
- 47.  $x=-4.5$
- 51.  $x=2$
- 55.  $y=0.5$
- 59.  $x=0.2$
- 63.  $n=3$
- 67.  $x=3$
- 71.  $y=0$
- 75.  $y=\frac{1}{5}$
- 79.  $x=-4$
- 81.  $x=-21$
- 85.  $y=1$
- 89.  $x=\frac{1}{4}$
- 93.  $x=-\frac{1}{4}$
- 97.  $x=\frac{2}{3}$
- 101.  $x=-11$
- 105.  $x=-5$
- 109.  $x=0$
- 113. Conditional
- 83.  $y=0$
- 87.  $x=-\frac{3}{2}$
- 91.  $x=\frac{3}{17}$
- 95.  $x=\frac{8}{5}$
- 99.  $x=6$
- 103.  $x=\frac{1}{2}$
- 107.  $n=-1.5$
- 111. Conditional
- 115. Contradiction

117. Identity      119. Conditional

121. a. The 4 should have been multiplied by 3 so that the 3 was distributed over the entire left-hand side of the equation; Correct answer is  $x = 15$ .

b. 3 should be subtracted from each side, not from each term, and  $5x - 3$  doesn't simplify to  $2x$ ; Correct answer is  $x = \frac{8}{5}$ .

123. a.  $x + 6 = 20$ ; conditional, since there is one age that will make the statement true

b.  $x + 6 = x + 8$ ; contradiction, since he can't be both 6 years older and 8 years older

c.  $x + 6 = (x + 3) + 3$ ; identity, since the statement will be true regardless of Ryan's current age

### 1.2 EXERCISES

1.  $r = \frac{C}{2\pi}$

3.  $a = \frac{v^2 - v_0^2}{2x}$

5.  $F = \frac{9}{5}C + 32$

7.  $h = \frac{A - 2lw}{2w + 2l}$

9.  $m = \frac{2K}{v^2}$

11.  $\frac{19}{3}$  hours, or 6 hours and 20 minutes

13. 13.5 miles      15. \$390

17. 2 gallons 44%, 1 gallon 50%

19. 24 child tickets, 15 adult tickets

21. 7.5%

23. 26 feet by 26 feet

25. 53, 55, and 57

27. 36.4%

29.  $x \approx 0.72$       31.  $x \approx 13.11$

### 1.3 EXERCISES

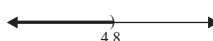
1.  $\{-9, 3.14, -2.83, 1, -3, 4\}$

3.  $\{-2.83, 1, -3\}$

5.  $(-\infty, -3]$



7.  $(-\infty, 4.8)$



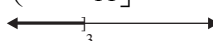
9.  $(-\infty, 2.25)$



11.  $(-\infty, \frac{3}{2})$



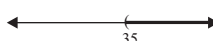
13.  $(-\infty, -\frac{3}{11}]$



15.  $(7, \infty)$



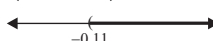
17.  $(35, \infty)$



19.  $(-3, \infty)$



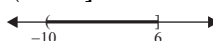
21.  $(-0.11, \infty)$



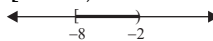
23.  $(1, 5]$



25.  $(-10, 6]$



27.  $[-8, -2)$



29.  $(21, 69]$



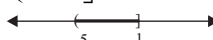
31.  $(\frac{23}{7}, \frac{25}{7})$



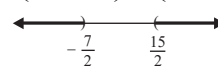
33.  $(\frac{13}{2}, 16)$



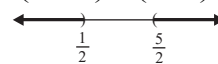
35.  $(-\frac{5}{3}, 1]$



37.  $(-\infty, -\frac{7}{2}) \cup (\frac{15}{2}, \infty)$



39.  $(-\infty, \frac{1}{2}) \cup (\frac{5}{2}, \infty)$



41.  $\emptyset$

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



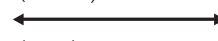
45.  $\emptyset$

47.  $\emptyset$

49.  $[-4, 0]$



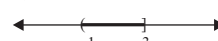
51.  $(-\infty, \infty)$



53.  $(3, 15)$



55.  $(-1, 3]$



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



59.  $[-2, 3)$



61.  $[73, 113]$  for an A,  
 $(113, 115)$  for an A+.

63.  $(1140, 1600]$

### 1.4 EXERCISES

1.  $\{\frac{3}{2}, -1\}$       3.  $\{7\}$

5.  $\{\frac{-3}{2}, -3\}$       7.  $\{-3, 1\}$

9.  $\{2\}$       11.  $\{3, 11\}$

13.  $\{0, 6\}$       15.  $\{\frac{-1 \pm \sqrt{7}}{2}\}$

17.  $\{\frac{-5}{3}, \frac{1}{3}\}$       19.  $\{-5, 9\}$

21.  $\{\frac{6}{5}, 6\}$       23.  $\{-5, 2\}$

25.  $\{\frac{-7}{2}, \frac{9}{2}\}$       27.  $\{\frac{13}{2}, \frac{15}{2}\}$

29.  $\{-25, -1\}$  31.  $\left\{-\frac{4}{3}, 1\right\}$   
 33.  $\{-1\}$  35.  $\left\{\frac{-1 \pm \sqrt{13}}{6}\right\}$   
 37.  $\left\{-\frac{3}{2}, 5\right\}$  39.  $\{-14, -6\}$   
 41.  $\{2, 14\}$  43.  $\left\{\frac{-1 \pm \sqrt{7}}{2}\right\}$   
 45.  $\{-16, 12\}$  47.  $\{-7, -6\}$   
 49.  $\{0, 6\}$  51.  $\{-1, 2\}$   
 53.  $\left\{1, 2, \frac{3 \pm \sqrt{17}}{2}\right\}$   
 55.  $(3x-1-\sqrt{5})(3x-1+\sqrt{5})$   
 57.  $b = -5$  and  $c = -24$

### 1.5 EXERCISES

1.  $\{-3, 4\}$  3.  $\{8, 13\}$   
 5.  $\{\pm\sqrt{2}, \pm i\sqrt{5}\}$   
 7.  $\{1 \pm 2i, 1 \pm \sqrt{3}\}$   
 9.  $\left\{\frac{1}{8}, 27\right\}$  11.  $\{\pm 2i, \pm 3\}$   
 13.  $\{-1, \pm 2, 3\}$  15.  $\left\{1, -\frac{8}{27}\right\}$   
 17.  $\{-1, -2, -3\}$  19.  $\{\pm 1, 3\}$   
 21.  $\left\{-\frac{5}{2}, 0, 3\right\}$  23.  $\{\pm 2, \pm 5i\}$   
 25.  $\left\{\pm 2, -\frac{6}{5}\right\}$  27.  $\left\{\pm \frac{3}{2}, \pm \frac{3i}{2}\right\}$   
 29.  $\left\{-\frac{5}{2}, 0, \frac{4}{7}\right\}$   
 31.  $\left\{-\frac{4}{3}, \frac{2 \pm 2i\sqrt{3}}{3}\right\}$   
 33.  $\left\{-3, \frac{3 \pm 3i\sqrt{3}}{2}\right\}$

35.  $\left\{\frac{5}{2}\right\}$  37.  $\{1\}$   
 39.  $\{4\}$  41.  $\{0, 2, 3\}$   
 43.  $\left\{-\frac{1}{5}, \frac{1}{7}\right\}$  45.  $\left\{-1, 0, \frac{2}{5}\right\}$   
 47.  $\left\{\frac{8}{3}\right\}$  49.  $\left\{-3, -\frac{13}{4}\right\}$   
 51.  $b = -4$ ,  $c = -12$ , and  $d = 0$   
 53.  $a = 1$ ,  $c = -36$ , and  $d = -144$   
 55.  $a = 15$ ,  $b = -16$ , and  $c = -5$

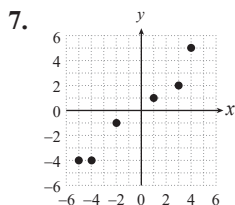
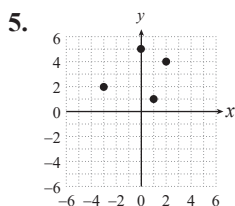
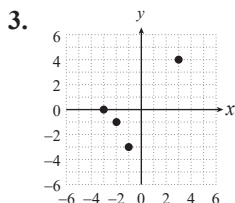
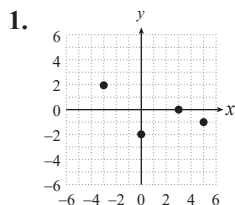
### 1.6 EXERCISES

1.  $x = 7$   
 3.  $x \neq 0, 2$ ;  $x = 4$   
 5.  $x \neq -3, 4$ ;  $x = -10$   
 7.  $x \neq 0$ ;  $x = 18$   
 9.  $x \neq 6$ ;  $x = -\frac{74}{9}$   
 11.  $x = \frac{1}{4}$   
 13.  $x = 6$  15.  $x = 4$   
 17.  $x \neq 0$ ;  $x = \frac{10}{3}$   
 19.  $x \neq 0$ ;  $x = -\frac{3}{4}$   
 21.  $x \neq 0$ ;  $x = -\frac{3}{16}$   
 23.  $x \neq -9, -\frac{1}{4}, 0$ ;  $x = -2, 1$   
 25.  $x \neq \frac{3}{2}, 0, 6$ ;  $x = \frac{3}{5}, 9$   
 27.  $x \neq \frac{1}{2}, 4$ ;  $x = -3$   
 29.  $x \neq -4, -1$ ;  $x = 2$

31.  $x \neq -1, \frac{1}{4}$ ;  $x = \frac{2}{3}$   
 33.  $x \neq 2, 3$ ;  $x = \frac{13}{10}$   
 35.  $x \neq -\frac{2}{3}, 2$ ; no solution  
 37.  $x \neq -1, \frac{1}{3}, \frac{1}{2}$ ;  $x = \frac{1}{5}$   
 39.  $\{0\}$  41.  $\{1\}$   
 43.  $\emptyset$  45.  $\{6\}$   
 47.  $\emptyset$  49.  $\{10\}$   
 51.  $\{1\}$  53.  $\{-2, 0, 2\}$   
 55.  $\emptyset$  57.  $\{4, 44\}$   
 59.  $\{0, 5\}$  61.  $\{4\}$   
 63.  $\{2\}$  65.  $\{-32\}$   
 67.  $\left\{\pm \frac{125}{343}\right\}$  69.  $\{7, 10\}$   
 71.  $\{\pm 3\}$   
 73. 144 defective bulbs  
 75. 370 at bats  
 77. 7.5 inches by 10 inches  
 79. 8.8 quarts  
 81. a. 7.5 miles per hour  
     b. 55 miles per hour  
 83. 5 hours  
 85. a.  $x = 10$   
     b. 8 kilometers per mile  
     c. 12 kilometers per mile  
     d. 0.5 hour  
 87. a.  $\frac{x^2 - 8x}{4(x-4)(x+4)}$   
     b.  $x = 0, 8$   
 89. a.  $\frac{14x-16}{5x(x-4)}$  b.  $x = \frac{8}{7}$

## Chapter 2: Linear Equations in Two Variables

### 2.1 EXERCISES



9. III                      11. IV

13. Positive  $x$ -axis

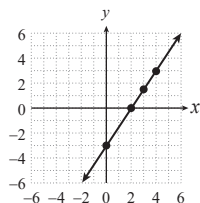
15. III                      17. IV

19. II                        21. IV

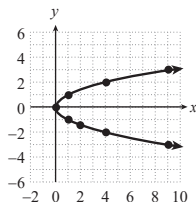
23. I

25. Negative  $y$ -axis

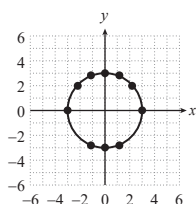
27.  $\left\{ (0, -3), (2, 0), \left(3, \frac{3}{2}\right), (4, 3) \right\}$



29.  $\left\{ (0, 0), (1, \pm 1), (4, \pm 2), (9, \pm 3), (2, -\sqrt{2}) \right\}$



31.  $\left\{ (0, \pm 3), (\pm 3, 0), (-1, \pm 2\sqrt{2}), (1, \pm 2\sqrt{2}), (\pm\sqrt{5}, 2) \right\}$



33.  $\sqrt{34}, \left( \frac{-7}{2}, \frac{1}{2} \right)$

35.  $\sqrt{58}, \left( \frac{3}{2}, \frac{7}{2} \right)$

37.  $2\sqrt{2}, (-1, -1)$

39.  $4\sqrt{34}, (3, -8)$

41. 10, (1, -6)

43.  $3\sqrt{13}, \left( 2, \frac{1}{2} \right)$

45.  $10\sqrt{2}, (3, 3)$

47.  $x = 2$  or 18

49.  $x = 10, y = 1$

51. 12

53.  $2\sqrt{29} + \sqrt{26} + 5\sqrt{2}$

55. 54

57. 1.25 kilometers

59. a. 249.19 meters

b.  $\left( \frac{133}{2}, \frac{709}{2} \right)$

61. area =  $\frac{15}{2}$                       63. area = 25

65. area = 17                      67. area = 48

69.  $x = [-5, 6]; y = [-8, 9]$

71.  $x = [-3, 6]; y = [-4, 5]$

73.  $x = [-6, 8]; y = [-9, 7]$

### 2.2 EXERCISES

1. Yes                          3. No

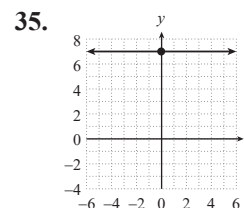
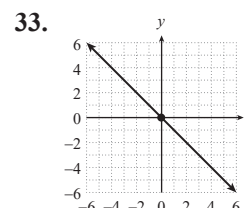
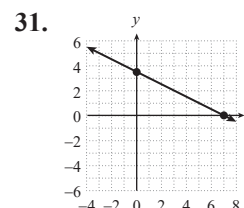
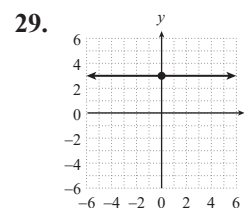
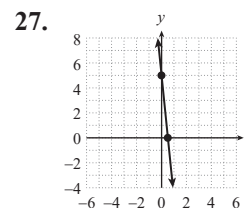
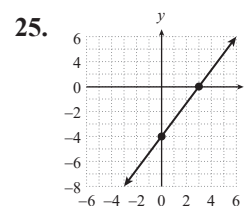
5. No                            7. No

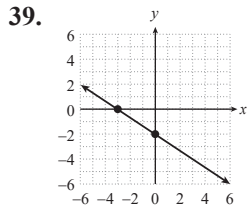
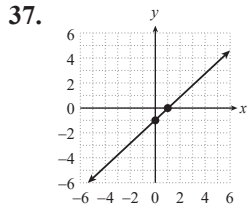
9. Yes                          11. Yes

13. Yes                        15. No

17. No                         19. No

21. No                         23. Yes





41. e                      43. c

45. f

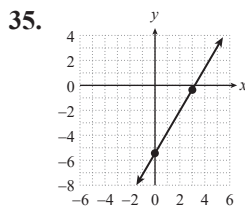
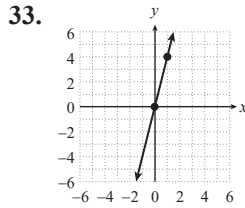
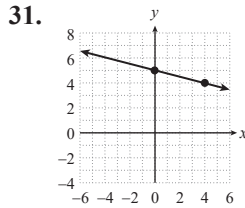
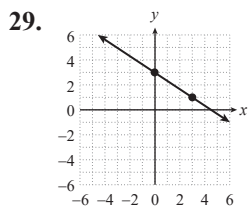
47.  $a = P - b - c$

49.  $j = 24,000 + 9b;$

$b = \frac{j - 24,000}{9};$  Yes

**2.3 EXERCISES**

- 1. -4                      3. 0
- 5. Undefined            7.  $\frac{2}{3}$
- 9.  $\frac{1}{6}$                       11. -7
- 13. -3                      15.  $-\frac{9}{13}$
- 17.  $-\frac{1}{4}$                       19. 0
- 21. Undefined            23. 2
- 25.  $\frac{7}{6}$                       27.  $-\frac{5}{2}$



37.  $y = \frac{3}{4}x - 3$

39.  $y = -\frac{5}{2}x - 7$

41.  $y = -5x - 9$

43.  $3x - 2y = 3$

45.  $y = 5$

47.  $10x - y = 31$

49.  $3x + y = 26$

51.  $4x + 3y = 5$

53.  $x = 2$                       55.  $y = -1$

57.  $2x + 7y = 52$

59.  $y = 5$

61.  $15x - 8y = 0$

63. c                      65. e

67. d

69. a. \$2225    b. \$2100

c. \$0.25

71. \$325

**2.4 EXERCISES**

- 1.  $y = 4x + 9$             3.  $y = 3x - 11$
- 5.  $y = -9$                       7.  $y = x$

9.  $y = \frac{7}{6}x + \frac{53}{6}$

11. Yes                      13. Yes

15. Yes                      17. No

19. No                      21. No

23. No                      25. No

27. Yes                      29. No

31.  $y = -\frac{1}{3}x - 1$             33.  $y = 7$

35.  $y = -\frac{1}{4}x - \frac{3}{4}$

37.  $y = x + 3$

39.  $y = -3x + 28$

41. No                      43. No

45. No                      47. No

49. Yes                      51. No

53. No                      55. No

57. Yes                      59.  $\frac{125}{3}$  ft

**2.5 EXERCISES**

- 1. Positive linear correlation
- 3. Negative linear correlation
- 5. Strong negative relationship
- 7. Weak positive relationship
- 9. No                      11. Yes
- 13. a. 606.04    b. 886.14  
c. 1138.23
- 15. a. Negative    b.  $r = -0.538$   
c. No
- 17. a. Positive    b.  $r = 0.903$   
c. Yes
- 19. a.  $\hat{y} = 0.344x + 1.134$   
b. Yes,  $r = 0.728$   
c. 3.886, or about 4 times
- 21. a.  $\hat{y} = 0.429x + 0.4$   
b. No,  $r = 0.407$   
c. N/A

## Chapter 3: Functions and Their Graphs

### 3.1 EXERCISES

1. a. 3    b. -11  
c.  $2a - 5$     d.  $2a - 6$
3. a. 9    b. 4  
c.  $a^2$     d.  $a^2 - 2a + 2$
5. a. 4    b. -8  
c.  $a^3 + 4a^2 + 2a$   
d.  $a^3 + a^2 - 3a + 2$
7. a. 35  
b.  $4a^2 + 16a + 15$   
c.  $4x^2 + 8xh + 4h^2 - 1$   
d. 12
9. a. 2    b.  $\sqrt{a+7}$   
c.  $\sqrt{x+h+5}$     d.  $3 - \sqrt{6}$
11. a. -5    b. -2  
c. 0.25    d. 3
13.  $3h$                       15.  $h^2 + 2hx$
17.  $2h^2 + 4hx$     19.  $h^2 + 2hx - h$
21.  $3h - h^2 - 2hx$
23.  $2h^2 + 4xh - 3h$
25.  $h^3 + 3h^2x + 3hx^2$
27.  $h^3 + 3h^2x + 3hx^2$
29.  $x \geq -5$               31.  $x > -10$
33.  $x \neq -1$               35.  $\mathbb{R}$
37.  $x > -\frac{5}{2}$               39.  $\mathbb{R}$
41. Is a function
43. Is a function
45. Is a function
47. Not a function
49. Not a function
51. Is a function

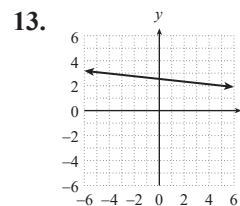
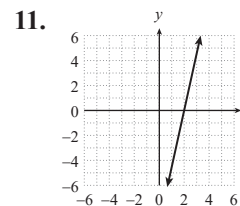
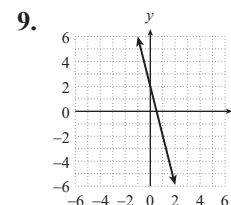
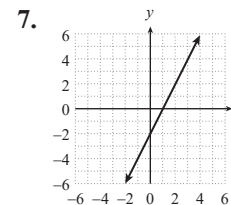
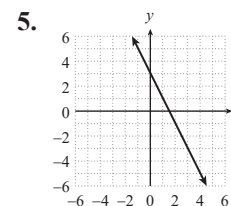
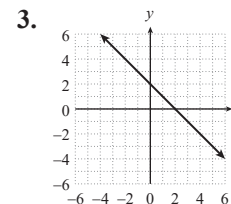
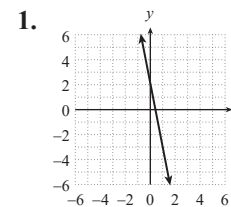
### 3.2 EXERCISES

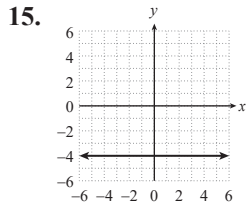
1.  $x = 3$                       3.  $x = 30, 50$
5. (4, 11)                      7. (5, 30)
9. a                              11. c
13. a                              15. a
17. a

19. a.  $C(x) = 135 + 0.5x$   
b. \$385
21. a.  $P(x) = 4.5x - 135$   
b. \$2115
23.  $P(x) = 100(4.5x - 135)$
25. 0.75 atm
27. 56.03 atm
29. a.  $R(x) = 6.5x$   
b.  $C(x) = 1.1x + 378$   
c.  $P(x) = 5.4x - 378$   
d.  $x = 70$  pies
31. a.  $R(x) = 243x$   
b.  $C(x) = 73x + 5780$   
c.  $P(x) = 170x - 5780$   
d.  $x = 34$  sets of clubs
33. a. \$0.15/pen  
b.  $C(x) = 0.15x + 260$   
c. \$260
35. a.  $R(x) = 31x - 0.5x^2$   
b.  $P(x) = -0.5x^2 + 20x - 500$
37. a.  $D(x) = -0.02x + 400$   
b.  $R(x) = -0.02x^2 + 400x$   
c.  $P(x) = -0.01x^2 + 150x - 3600$
39. a.  $I = 0.0625P$   
b. \$375
41. a.  $p = \frac{340}{x}$     b. \$10
43. The least integer  $y$  such that  $y \geq \frac{800}{x}$
45.  $C(x) = \begin{cases} 0.65; & \text{for } 0 < x \leq 3 \\ 0.65 + 0.15(x-3); & \text{for } x > 3 \end{cases}$

47.  $P(x) = 0.2575x$
49.  $P(x) = -x^2 + 72x - 720$
51.  $A(x) = 138x - x^2$
53.  $P(x) = \frac{576}{x} + 2x$
55.  $A(x) = 360x - \frac{3}{2}x^2$

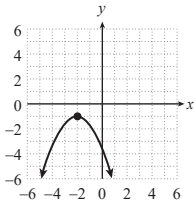
### 3.3 EXERCISES



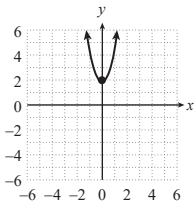


17. b                      19. a

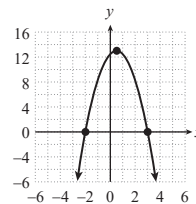
21. Vertex:  $(-2, -1)$ ; no  $x$ -int.



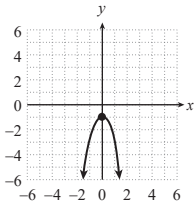
23. Vertex:  $(0, 2)$ ; no  $x$ -int.



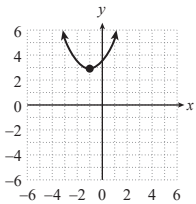
25. Vertex:  $(\frac{1}{2}, \frac{25}{2})$ ;  $x$ -int.:  $x = -2, 3$



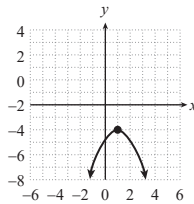
27. Vertex:  $(0, -1)$ ; no  $x$ -int.



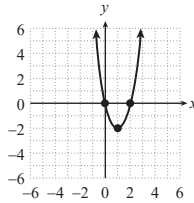
29. Vertex:  $(-1, 3)$ ; no  $x$ -int.



31. Vertex:  $(1, -4)$ ; no  $x$ -int.



33. Vertex:  $(1, -2)$ ;  $x$ -int.:  $x = 0, 2$



35. c                      37. a

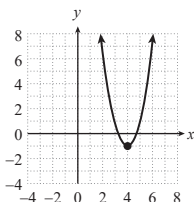
39. a. 1, on  
 b. 2, below  
 c. 2, above  
 d. 2, above  
 e. 2, below  
 f. none, below

### 3.4 EXERCISES

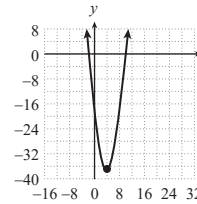
- Width of 50 feet, length of 100 feet
- Width and length are 5
- $(8, 4)$
- 8 and 8
- 11,250 square feet

- 500 rooms
- 1500 cars
- 6050 square feet
- 180 feet

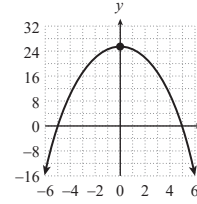
19. Vertex:  $(4, -1)$ ;  
 $x$ -int.:  $x = \frac{8 \pm \sqrt{2}}{2}$



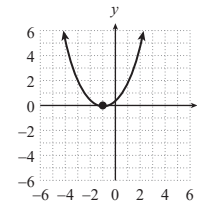
21. Vertex:  $(4, -36)$ ;  
 $x$ -int.:  $x = -2, 10$



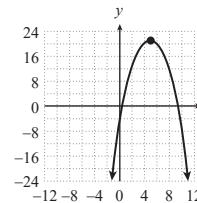
23. Vertex:  $(0, 25)$ ;  $x$ -int.:  $x = -5, 5$



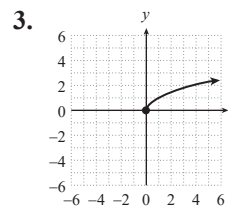
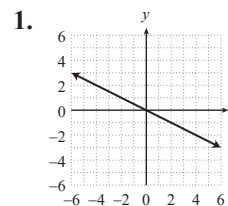
25. Vertex:  $(-1, 0)$ ;  $x$ -int.:  $x = -1$

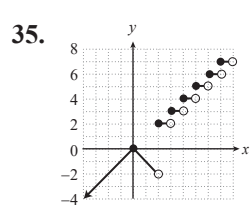
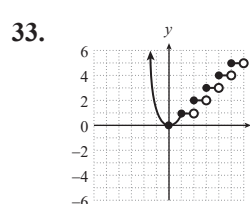
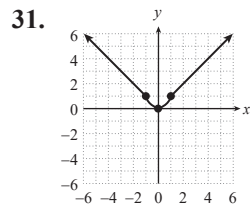
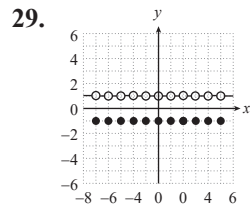
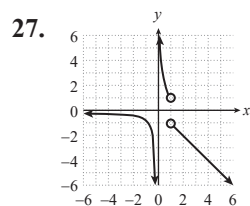
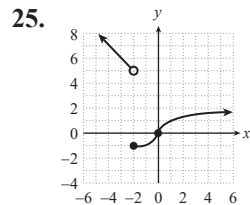
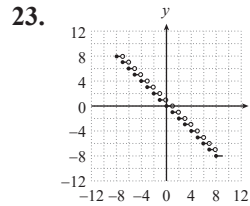
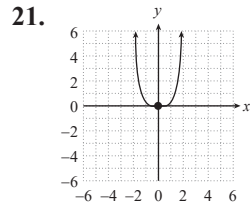
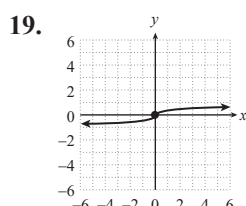
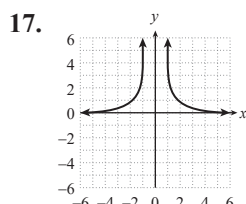
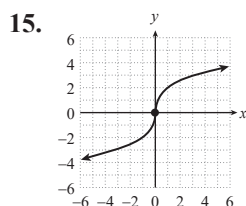
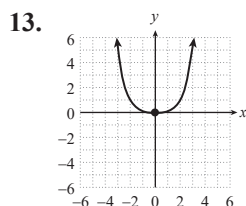
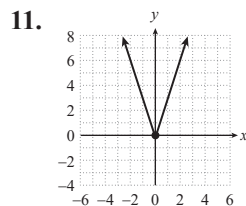
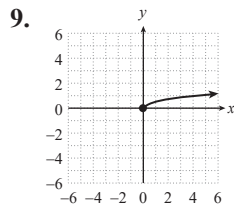
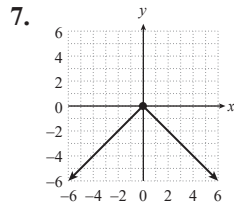
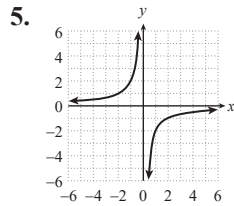


27. Vertex:  $(5, 21)$ ;  
 $x$ -int.:  $x = 5 \pm \sqrt{21}$



### 3.5 EXERCISES





37. j

39. a

41. i

43. e

45. f

### 3.6 EXERCISES

1.  $y = x^2$

3.  $y = \sqrt[3]{x}$

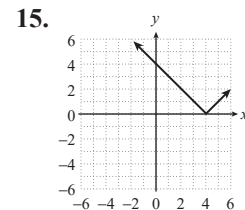
5.  $y = \sqrt{x}$

7.  $y = \frac{1}{x^2}$

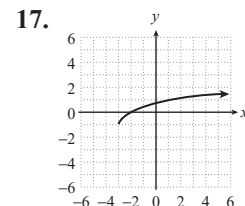
9.  $y = x^3$

11.  $y = \sqrt{x}$

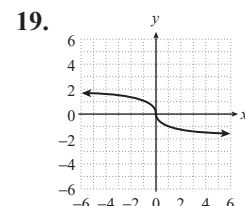
13.  $y = x^3$



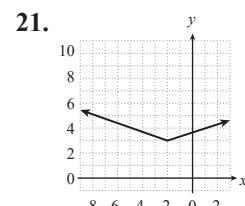
Dom =  $\mathbb{R}$ , Ran =  $[0, \infty)$



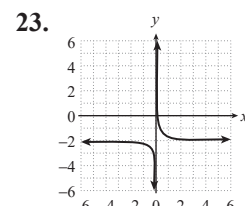
Dom =  $[-3, \infty)$ , Ran =  $[-1, \infty)$



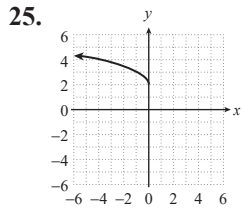
Dom = Ran =  $\mathbb{R}$



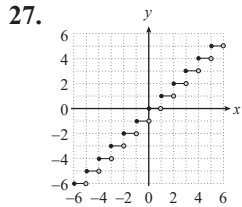
Dom =  $\mathbb{R}$ , Ran =  $[3, \infty)$



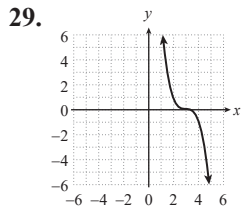
Dom =  $(-\infty, 0) \cup (0, \infty)$ ,  
Ran =  $(-\infty, -2) \cup (-2, \infty)$



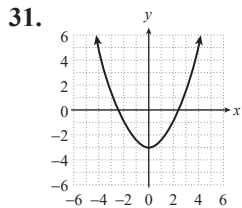
Dom =  $(-\infty, 0]$ , Ran =  $[2, \infty)$



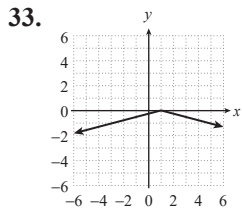
Dom =  $\mathbb{R}$ , Ran =  $\mathbb{Z}$



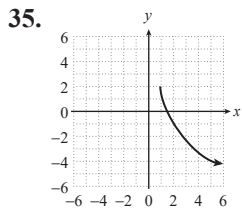
Dom = Ran =  $\mathbb{R}$



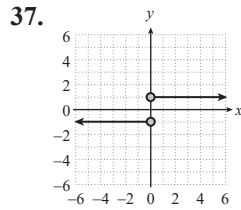
Dom =  $\mathbb{R}$ , Ran =  $[-3, \infty)$



Dom =  $\mathbb{R}$ , Ran =  $(-\infty, 0]$

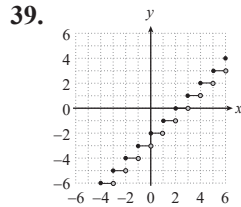


Dom =  $[1, \infty)$ , Ran =  $(-\infty, 2]$



Dom =  $(-\infty, 0) \cup (0, \infty)$ ,

Ran =  $\{-1, 1\}$



Dom =  $\mathbb{R}$ , Ran =  $\mathbb{Z}$

41.  $f(x) = (x - 4)^2 + 2$

43.  $f(x) = (-x - 2)^2 = (x + 2)^2$

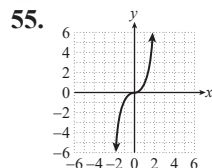
45.  $f(x) = (x - 10)^3 + 4$

47.  $f(x) = \sqrt{-x} - 3$

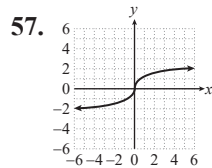
49.  $f(x) = -|x - 8| - 2$

51.  $f(x) = -\sqrt{x + 4}$

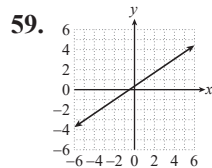
53.  $f(x) = 1 - (x - 3)^3$



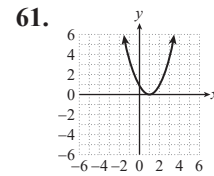
Odd function; origin symmetry



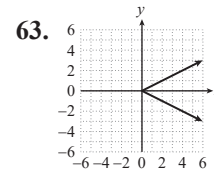
Odd function; origin symmetry



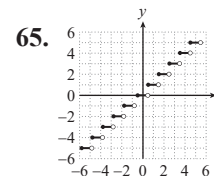
Function; neither; none of the symmetries



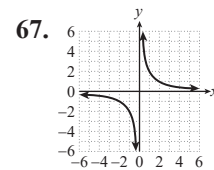
Function; neither; none of the symmetries



Not a function; x-axis symmetry



Function; neither; none of the symmetries



Odd function; Origin symmetry

69. Dec. on  $(-\infty, -3)$ ,  
Inc. on  $(-3, \infty)$

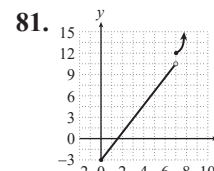
71. Dec. on  $(-\infty, 1)$ , Dec. on  $(1, \infty)$

73. Inc. on  $(-1, \infty)$

75. Inc. on  $(-\infty, 1)$ , Dec. on  $(1, \infty)$

77. Inc. on  $(-\infty, 7)$ , Dec. on  $(7, \infty)$

79. Dec. on  $(-\infty, 1)$ , Inc. on  $(1, 3)$ ,  
Dec. on  $(3, \infty)$



Inc. on  $(0, \infty)$

89.  $f(x) = -(x + 3)^2 + 5$

91.  $f(x) = -x^3 + 7$

93.  $f(x) = (x - 2)^3 - 4$

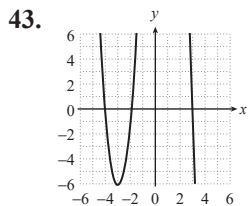
### 3.7 EXERCISES

19. Yes

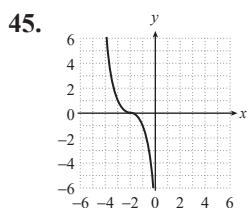
21. Yes

23. Yes                      25.  $1 \pm 2i$   
 27.  $-3, \frac{1}{2}$                 29.  $\pm\sqrt{3}, \pm\sqrt{5}$   
 31.  $-\frac{5}{2}$                     33.  $0, 4 \pm 3i$

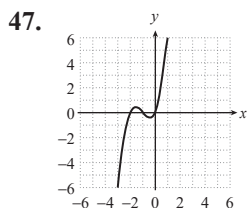
35.  $\pm 1, \pm 2i\sqrt{2}$   
 37. 7<sup>th</sup>-degree; lead coef. = 4;  
 $j(x) \rightarrow -\infty$  as  $x \rightarrow -\infty$   
 $j(x) \rightarrow \infty$  as  $x \rightarrow \infty$   
 39. 5<sup>th</sup>-degree; lead coef. = -6;  
 $h(x) \rightarrow \infty$  as  $x \rightarrow -\infty$   
 $h(x) \rightarrow -\infty$  as  $x \rightarrow \infty$   
 41. 4<sup>th</sup>-degree; lead coef. = -2;  
 $f(x) \rightarrow -\infty$  as  
 $x \rightarrow -\infty$  and  $x \rightarrow \infty$



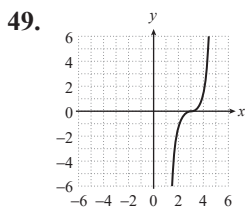
$g(x) \rightarrow \infty$  as  $x \rightarrow -\infty$ ;  
 $g(x) \rightarrow -\infty$  as  $x \rightarrow \infty$   
 x - int :  $(-4, 0), (-2, 0), (3, 0)$ ;  
 y - int :  $(0, 24)$



$h(x) \rightarrow \infty$  as  $x \rightarrow -\infty$ ;  
 $h(x) \rightarrow -\infty$  as  $x \rightarrow \infty$   
 x - int :  $(-2, 0)$ ;  
 y - int :  $(0, -8)$



$s(x) \rightarrow -\infty$  as  $x \rightarrow -\infty$ ;  
 $s(x) \rightarrow \infty$  as  $x \rightarrow \infty$   
 x - int :  $(-2, 0), (-1, 0), (0, 0)$ ;  
 y - int :  $(0, 0)$



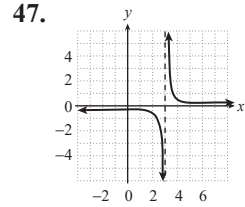
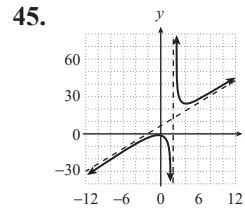
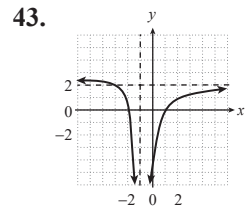
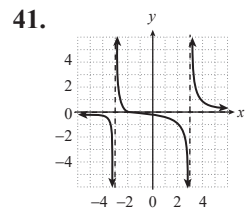
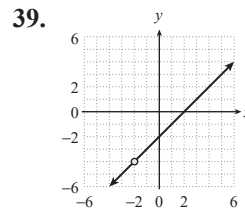
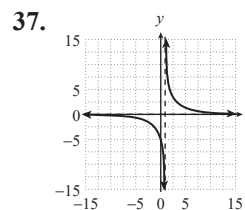
$g(x) \rightarrow -\infty$  as  $x \rightarrow -\infty$ ;  
 $g(x) \rightarrow \infty$  as  $x \rightarrow \infty$   
 x - int :  $(3, 0)$ ;  
 y - int :  $(0, -243)$

51. e                      53. a  
 55. f                      57. d  
 59. f                      61. b  
 63.  $(-\infty, -2) \cup (3, \infty)$   
 65.  $(-\infty, -2) \cup (-1, 0)$   
 67.  $[-2, 1] \cup [3, \infty)$   
 69.  $[-5, -1] \cup [1, 4]$   
 71.  $(-\frac{1}{2}, 2)$   
 73.  $(-\infty, -4) \cup (2, 3)$   
 75. All integers between 5 and 27,  
 inclusive  
 77. All integers between 11 and 23,  
 inclusive  
 79. Between 3490 and 17,740  
 phones, inclusive.  
 81. About 141.4 weeks

**3.8 EXERCISES**

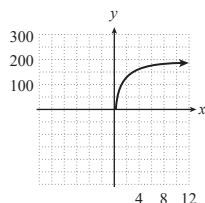
1.  $x = 1$   
 3. No vertical asymptote  
 5.  $x = 2$                       7.  $x = 0$   
 9.  $x = -\frac{1}{2}$   
 11. No vertical asymptote  
 13.  $x = 7$                       15.  $x = -2$   
 17.  $x = -2, x = 2$   
 19.  $y = 0$   
 21. No horizontal or oblique  
 asymptote  
 23.  $y = 0$                       25.  $y = 2$   
 27.  $y = 3x + 6$                 29.  $y = 0$   
 31.  $y = 0$

33.  $y = x - 11$               35.  $y = 5x + 4$



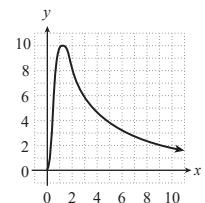
49. a.  $x = -2$               b.  $y = 0$   
 c. None                      d. None  
 e.  $(0, 5)$   
 51. a.  $x = 9$                 b.  $y = 0$   
 c. None                      d. None  
 e.  $(0, -\frac{1}{3})$   
 53. a.  $x = -1, x = 1$   
 b. None                      c.  $y = x$   
 d.  $(\sqrt[3]{3}, 0)$                 e.  $(0, 3)$   
 55. a.  $x = 1$                 b. None  
 c.  $y = 3x$                 d. None  
 e.  $(0, -3)$

57. a.



b. April's fish population approaches a maximum of 200 fish.

59. a.



b. The concentration of the drug disappears in the long run.

### 3.9 EXERCISES

1.  $(-\infty, -4] \cup [0, \infty)$

3.  $(-\infty, -6)$

5.  $(-\infty, -9) \cup (-3, \infty)$

7.  $(2, \frac{5}{2})$       9.  $(7, \infty)$

11.  $[\frac{7}{5}, 4)$       13.  $(-9, -\frac{4}{3})$

15.  $(-\infty, -4] \cup [0, 3)$

17.  $(-2, 0) \cup [5, \infty)$

19.  $(-\infty, -2) \cup (-1, 1)$

21.  $(-8, -2) \cup (2, \infty)$

23.  $(-\infty, -2) \cup (-2, 3)$

25.  $(0, 3)$

27.  $(-2, -1) \cup (1, \infty)$

29.  $(-\infty, -1) \cup [-\frac{1}{2}, 0)$

31. a.  $(-4, 0) \cup (1, \infty)$

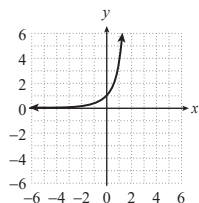
b.  $(-\infty, -4) \cup (0, 1)$

c. The function is undefined at  $x = 0$ .

## Chapter 4: Exponential and Logarithmic Functions

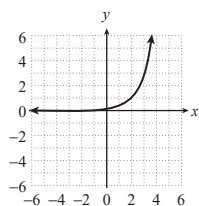
### 4.1 EXERCISES

1.



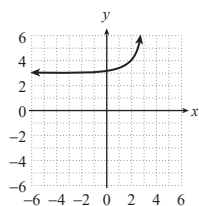
Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$

3.



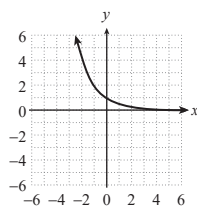
Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$

5.



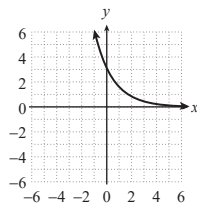
Dom =  $(-\infty, \infty)$ , Ran =  $(3, \infty)$

7.



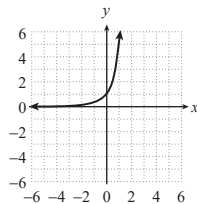
Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$

9.



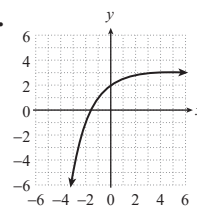
Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$

11.



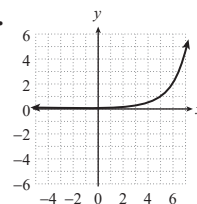
Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$

13.



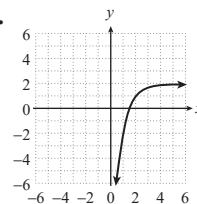
Dom =  $(-\infty, \infty)$ , Ran =  $(-\infty, 3)$

15.

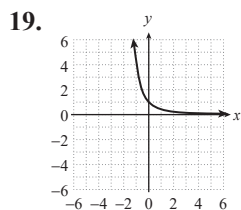


Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$

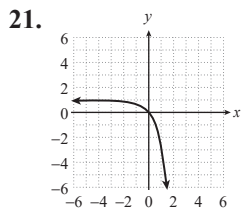
17.



Dom =  $(-\infty, \infty)$ , Ran =  $(-\infty, 2)$



Dom =  $(-\infty, \infty)$ , Ran =  $(0, \infty)$



Dom =  $(-\infty, \infty)$ , Ran =  $(-\infty, 1)$

23.  $\{2\}$                       25.  $\{-2\}$   
 27.  $\{-13\}$                     29.  $\{3\}$   
 31.  $\{-2\}$                       33.  $\{-2, -1\}$   
 35.  $\{7\}$                         37.  $\{3\}$   
 39.  $\{9\}$                         41.  $\{-3\}$   
 43.  $\{2\}$                         45.  $\{-1\}$   
 47. a                            49. i  
 51. d                            53. e  
 55. h

### 4.2 EXERCISES

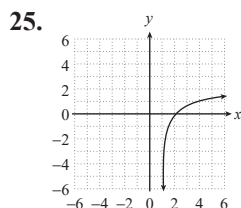
1.  $V \approx 178$  people
3.  $C \approx \$8526.20$
5.  $W \approx 93$  computers
7. a.  $a \approx 0.999567$   
 b.  $A \approx 0.958$  grams  
 c.  $A \approx 0.648$  grams
9. a. 3 years  
 b. 9 years
11. 1118 rabbits
13. The bank offering 2.75% and monthly compounding.
15. Approximately 3.18%
17. \$134,392
19. a. 10  
 b. 7490 people  
 c. The function approaches 10,000 as time goes on.

21. a.  $a \approx 0.965936$   
 b.  $A \approx 0.707$  kg  
 c.  $A \approx 7.628$  mg
23. a. \$1521.74    b. \$271.74
25. \$9459.48; \$9942.41
27. \$2835.71    29. \$20,000
31. \$7318.71

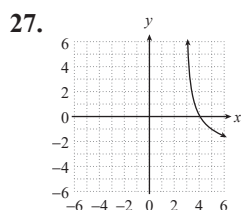
33. a. \$7647.95    b. \$7647.57  
 c. Yes; daily compounding is a frequency close enough to continuous compounding to make little difference at the hundredths place.

### 4.3 EXERCISES

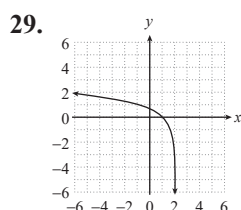
1.  $4 = \log_5 625$     3.  $3 = \log_x 27$
5.  $3 = \log_{4.2} C$     7.  $x = \log_4 31$
9.  $\sqrt{3} = \log_{4x} 13$     11.  $e^x = \log_2 11$
13.  $81 = 3^4$             15.  $4 = b^{\frac{1}{2}}$
17.  $15 = 2^b$             19.  $W = 5^{12}$
21.  $2x = \pi^4$             23.  $e^x = 2$



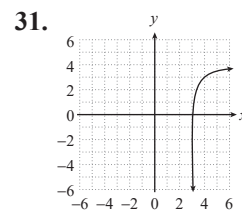
Dom:  $(1, \infty)$ , Ran:  $(-\infty, \infty)$



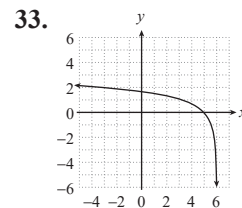
Dom:  $(3, \infty)$ , Ran:  $(-\infty, \infty)$



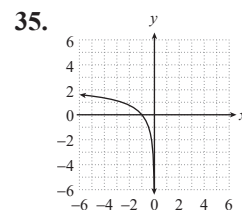
Dom:  $(-\infty, 2)$ , Ran:  $(-\infty, \infty)$



Dom:  $(3, \infty)$ , Ran:  $(-\infty, \infty)$



Dom:  $(-\infty, 6)$ , Ran:  $(-\infty, \infty)$



Dom:  $(-\infty, 0)$ , Ran:  $(-\infty, \infty)$

37. e                            39. b
41. h                            43. d
45. i                            47. -2
49. 3                            51.  $-\frac{1}{2}$
53.  $\frac{3}{4}$                             55. 2.89
57.  $\frac{5}{3}$                             59. 1
61.  $\frac{1}{5}$                             63. 2
65.  $\{64\}$                       67.  $\{9\}$
69.  $\{-\frac{1}{2}\}$                       71.  $\{\frac{1}{21}\}$
73.  $\{10\}$                       75.  $\{36\}$
77.  $\{\pm\frac{1}{10}\}$                       79.  $\{0.18\}$
81.  $\{\pm\sqrt{e}\}$  or  $\{\pm 1.65\}$
83.  $\{12.89\}$
85.  $\{10,000,000,002\}$

**4.4 EXERCISES**

- 1.  $3 + 3\log_5 x$
- 3.  $2 + \ln p - 3\ln q$
- 5.  $1 + \log_9 x - 3\log_9 y$
- 7.  $\frac{3}{2}\ln x + \ln p + 5\ln q - 7$
- 9.  $\log(2 + 3\log x)$
- 11.  $1 - \frac{1}{2}\log(x + y)$
- 13.  $\log_2(y^2 + z) - 4\log_2 x - 4$
- 15.  $2\log_b x + \frac{1}{2}\log_b y - \log_b z$
- 17.  $2 + \log_b a + b\log_b c$
- 19.  $\log \frac{x}{y}$
- 20.  $\log_5(x + 5)$
- 23.  $\log_2\left(x^{\frac{4}{3}} + 3x^{\frac{1}{3}}\right)$
- 25.  $\ln\left(\frac{3p}{q^2}\right)$
- 27.  $\log\left(\frac{x-10}{x}\right)$
- 29.  $\ln\left(\frac{z^2}{x^3y^3}\right)$
- 31.  $\log_5 4$
- 33.  $\ln 45$
- 35.  $\log_3 1 = 0$
- 37.  $\ln 12$
- 39.  $\log 11$
- 41.  $\log_8(x^2 - y)$
- 43.  $x^2$
- 45.  $\frac{e^2 p}{x}$
- 47.  $\frac{x^3}{y^4}$
- 49.  $x^2$
- 51. 4
- 53.  $12x^2$
- 55. 2.04
- 57. 0.95
- 59. 0.95
- 61. 2.45
- 63. 3.30
- 65. 0.74
- 67. 1.20
- 69. 1.86
- 71. -1
- 73. 3.85
- 75. 0.77
- 77. -1.76
- 79. 2
- 81. 7
- 83. 1
- 85.  $4\sqrt{2} \approx 5.66$
- 87. 9.05
- 89. 2.08
- 91. 12
- 93. 1,048,576
- 95. 10.25
- 97. 5,011,872 times stronger
- 99. 133 decibels
- 101. 7.62; yes
- 103. a. 15.05 minutes  
b. 7:00 p.m. c. 112 °F; no

**Chapter 5: Mathematics of Finance**

**5.1 EXERCISES**

- 1. \$7200
- 3. Taxes are \$182.24/week; max. car payment is \$292.64/month
- 5. \$3890/month
- 7. \$11,700
- 9. \$189.88
- 11. \$117.06
- 13. \$164,285.71
- 15. \$312.50
- 17. \$6125

- 23. a. \$1770.36 b. \$1827.69  
c. \$1831.87 d. \$1832.95  
e. \$1833.13
- 25. a. \$3000 b. \$6000  
c. \$12,000 d. \$24,000

27.

First Bank of Lending Loan APY	
Loan Amount	APY
< \$20,000	11.73%
\$20,000–\$99,000	9.30%
≥ \$100,000	5.88%

**5.2 EXERCISES**

- 1. \$340
- 3. \$585
- 5. a. \$4786.91 b. \$2286.91
- 7. a. \$4788.57 b. \$2288.57
- 9. a. \$4692.84 b. \$2192.84
- 11. a. \$41,425.07 b. \$28,925.07
- 13. a. \$23,485.22 b. \$8485.22
- 15. a. \$93,940.86 b. \$33,940.86
- 17. \$1653.71
- 19. a. \$111,624.25 b. \$111,945.38
- 21. a. \$6000 b. \$7373.07  
c. \$7358.78

**5.3 EXERCISES**

- 1. \$11,263.09
- 3. \$34,233.00
- 5. \$782.48
- 7. \$773.91
- 9. a. \$17.91 b. \$39.39  
c. \$91.19
- 11. \$81,466.12
- 13. \$921.76
- 15. \$978.28
- 17. a. \$257.89  
b. \$46,420.20;  $I = \$28,579.80$
- 19. a. \$1,474,258.37  
b. Blake deposited \$232,200 and made \$1,242,058.37 in interest.

**5.4 EXERCISES**

- 1. a. \$641.73 b. \$7700.76
- 3. a. \$274.63 b. \$9886.68
- 5. a. \$261.70 b. \$6280.80
- 7. a. \$1240 b. \$4464
- 9. 0.9% financing for 48 months will cost \$29,492.16 total, and the cash back with 4.75% APR for 48 months will cost \$30,752.16 total. The 0.9% financing is the best option.
- 11. a. \$2599.60 b. \$124,780.80  
c. \$10,780.80
- 13. a. \$125.36 b. \$3008.64  
c. \$358.64
- 15. a. \$1266.71 b. \$206,015.60  
c. \$456,015.60 d. \$1912.48  
e. \$94,246.40 f. \$344,246.40
- 17. The five-year loan with an APR of 7.5% (\$400.76 monthly payment, \$4045.60 in interest paid)
- 19. 20.12 months, so 21 months, or about 1.7 years
- 21. a. \$169,024.96 b. \$247,502.21

## Chapter 6: Systems of Linear Equations; Matrices

### 6.1 EXERCISES

1.  $(-5, 2)$
3.  $(5, 3)$
5.  $\emptyset$
7.  $\left\{ \left( \frac{y-3}{2}, y \right) \mid y \in \mathbb{R} \right\}$
9.  $(-1, 7)$
11.  $(3, 11)$
13.  $\{(x, 4x+1) \mid x \in \mathbb{R}\}$
15.  $(2, 19)$
17.  $(-5, 1)$
19.  $(5, 6)$
21.  $\{(-y-2, y) \mid y \in \mathbb{R}\}$
23.  $(-5, 4)$
25.  $(-1, 1)$
27.  $(3, -5)$
29.  $\emptyset$
31.  $(-1, 3, 0)$
33.  $(2, 2, -1)$
35.  $\left\{ \left( \frac{y-z+2}{3}, y, z \right) \mid y \in \mathbb{R}, z \in \mathbb{R} \right\}$
37.  $\emptyset$
39.  $(1, 1, 0)$
41.  $(9, 1, 1)$
43.  $(3, 1, -2)$
45.  $(4, 5, 5)$
47.  $\left( \frac{49}{3}, \frac{-16}{3}, \frac{5}{4} \right)$
49.  $(0, 3, 2)$
51. 22 pennies, 23 nickels
53. 25 people
55. Eliza is 15 years old.
57. 7 shirts and  
4 pairs of shorts
59. 3 quarters,  
11 dimes, and  
28 pennies
61. Jim is 28 years old.
63. 3 thumb screws
65. Apples: \$0.78,  
Oranges: \$0.93,  
Mangos: \$1.05
67.  $(0.43, 1.28, 3.64)$
69.  $(-3.42, 2.98, 2.76)$
71.  $(6, 8, 7)$

### 6.2 EXERCISES

1. a.  $3 \times 2$  b.  $-1$   
c. None
3. a.  $5 \times 2$  b. None  
c. 10
5. a.  $3 \times 4$  b. None  
c. 286
7. a.  $3 \times 2$  b. 1  
c. None
9. a.  $2 \times 5$  b. 5  
c. 2
11.  $\left[ \begin{array}{ccc|c} -3 & 1 & -2 & -4 \\ \frac{1}{2} & -4 & -1 & 1 \\ 0 & -3 & 3 & 1 \end{array} \right]$
13.  $\left[ \begin{array}{ccc|c} -\frac{3}{2} & -1 & 0 & -1 \\ 2 & 2 & 3 & 0 \\ 0 & -1 & 6 & 0 \end{array} \right]$
15.  $\left[ \begin{array}{ccc|c} 12 & 1 & -\frac{3}{2} & \frac{1}{5} \\ 5 & 2 & -2 & \frac{1}{5} \\ 1 & 0 & 3 & 1 \\ 5 & 2 & 1 & -2 \end{array} \right]$
17.  $\left[ \begin{array}{ccc|c} 2 & -4 & -2 & 0 \\ 3 & -3 & -2 & 0 \\ 8 & -2 & 6 & 7 \\ 3 & -2 & 0 & 0 \end{array} \right]$
19.  $\left[ \begin{array}{ccc|c} \frac{1}{2} & -14 & -\frac{1}{4} & -8 \\ \frac{1}{5} & -\frac{7}{6} & \frac{1}{4} & -3 \\ 5 & -5 & \frac{8}{3} & -5 \end{array} \right]$
21.  $\begin{cases} x = 8 \\ y = 3 \end{cases}$
23.  $\begin{cases} x + 3y + 6z = 16 \\ y + 2z = 9 \\ z = 4 \end{cases}$
25.  $\begin{cases} 9y + 13z = 27 \\ 2x + 21z = 19 \\ 7x + 18y = 32 \end{cases}$
27.  $\left[ \begin{array}{cc|c} 2 & -5 & 3 \\ 0 & -7 & 5 \end{array} \right]$
29.  $\left[ \begin{array}{cc|c} 1 & 3 & -2 \\ 9 & -2 & 7 \end{array} \right]$
31.  $\left[ \begin{array}{cc|c} 8 & -2 & -4 \\ -6 & 2 & -14 \end{array} \right]$
33.  $\left[ \begin{array}{cc|c} 4 & 12 & -6 \\ 9 & 9 & 6 \end{array} \right]$
35.  $\left[ \begin{array}{cc|c} 4 & -1 & 5 \\ -6 & 2 & 0 \end{array} \right]$
37.  $\left[ \begin{array}{ccc|c} 18 & -6 & 15 & 42 \\ -7 & 19 & 2 & 3 \\ -4.5 & 5.5 & -2 & 3.5 \end{array} \right]$
39.  $\left[ \begin{array}{ccc|c} 5 & 18 & 22 & 5 \\ 32 & -9 & -27 & -23 \\ -9 & 21 & 12 & 9 \end{array} \right]$
41.  $\left[ \begin{array}{ccc|c} 0 & 1 & -9 & -3 \\ 1 & 1 & 3 & 4 \\ 0 & 0 & 0 & 0 \end{array} \right]$
43.  $\left[ \begin{array}{cc|c} -1 & 4 & -3 \\ 1 & -6 & \frac{5}{2} \end{array} \right]$
45.  $\left[ \begin{array}{ccc|c} 1 & 5 & -9 & 11 \\ 0 & -1 & 8 & -7 \\ 0 & -17 & 41 & 1 \end{array} \right]$
47. Neither
49. Neither
51. Neither
53.  $(3, -1)$
55.  $(1, 3)$
57.  $(-7, 3)$
59.  $\emptyset$
61.  $(3, 2)$
63.  $\{(-2y-4, y) \mid y \in \mathbb{R}\}$
65.  $\emptyset$
67.  $(4, 0, 3)$
69.  $(15, -21, 8)$
71.  $(3, -5)$
73.  $\{(x, -3x-2) \mid x \in \mathbb{R}\}$
75.  $(-4, 1)$
77.  $(6, 4)$
79.  $(-11, -5)$
81.  $(7, 3, 3)$
83.  $(2, 2, -1)$
85.  $\{(1, y, 0) \mid y \in \mathbb{R}\}$
87.  $(3, -2, 3)$
89.  $(2, 3, 4)$
91.  $(9, -19, 7)$
93.  $(1, -2, -1, 3)$
95. 42, 26, 87
97. Small: 10, Medium: 24, Large: 48

## 6.3 EXERCISES

1. 11                    3. 15  
 5.  $ab - x^2$             7. 8  
 9. -10                    11. -39  
 13.  $\{-2, 3\}$             15.  $\{-5, 1\}$   
 17.  $\{-5, -4\}$         19.  $\{-6, 4\}$   
 21.  $\{2, 5\}$               23. 3  
 25. -9                    27. 2  
 29. -2                    31. 159  
 33. 78                    35. -254  
 37. 404                   39. 4  
 41. 120                   43. 10  
 45.  $x^4$                    47.  $x^8$   
 49.  $(76, -53)$   
 51.  $\{(-y-2, y) \mid y \in \mathbb{R}\}$   
 53.  $\emptyset$   
 55.  $\{(-3z-5, -6z-10, z) \mid z \in \mathbb{R}\}$   
 57.  $\left\{ \left( \begin{array}{c} \frac{-5y-z-5}{2}, \\ \frac{-5y+3z-19}{2}, y, z \end{array} \right) \mid \begin{array}{l} y \in \mathbb{R}, \\ z \in \mathbb{R} \end{array} \right\}$   
 59.  $\left\{ \left( \begin{array}{c} -z+8, \\ -5z+31, \\ -2z+37, z \end{array} \right) \mid z \in \mathbb{R} \right\}$   
 61. (1647, 2071)  
 63.  $\emptyset$   
 65.  $(-3, -1, 0, -4)$   
 67. Candy bars: 5, Ice cream: 6  
 69. 0.012                71. 0.564  
 73. 1194                75.  $(1, -1, 2)$   
 77.  $(2, 1, 0, 3)$

## 6.4 EXERCISES

1.  $\begin{bmatrix} 5 & -1 \\ 0 & 0 \\ 2 & 13 \end{bmatrix}$                 3.  $\begin{bmatrix} 6 & -3 \\ 18 & 30 \\ -9 & 21 \end{bmatrix}$   
 5. Not possible  
 7.  $\begin{bmatrix} 14 & -14 \\ 8 & 0 \\ -4 & 14 \end{bmatrix}$                 9.  $\begin{bmatrix} -7 & 5 \\ 3 & 10 \\ -3 & -8 \end{bmatrix}$

11. Not possible  
 13.  $a = 3, b = -1, c = 10$   
 15.  $a = 2, b = -2, c = -1$   
 17. Not possible  
 19.  $x = 10, y = 5$   
 21.  $x = 3, y = 1$   
 23. Not possible  
 25.  $a = 8, b = 5$   
 27.  $\begin{bmatrix} 24 & -5 \end{bmatrix}$   
 29.  $\begin{bmatrix} 35 & 18 \end{bmatrix}$   
 31. Not possible  
 33.  $\begin{bmatrix} -30 & -3 \end{bmatrix}$   
 35.  $\begin{bmatrix} 15 & -3 & -24 \\ 25 & -5 & -40 \\ 30 & -6 & -48 \end{bmatrix}$   
 37.  $\begin{bmatrix} -34 & -7 \end{bmatrix}$   
 39.  $\begin{bmatrix} 11 & 0 \\ 0 & 11 \end{bmatrix}$   
 41.  $\begin{bmatrix} 32 & -20 \\ 56 & -35 \\ -16 & 10 \end{bmatrix}$   
 43. Not possible  
 45.  $\begin{bmatrix} 14 & -13 \\ -13 & 5 \end{bmatrix}$   
 47.  $\begin{bmatrix} 179 & 76 \end{bmatrix}$   
 49.  $\frac{2}{3}$  for store A;  $\frac{1}{3}$  for store B  
 51. Solution is incorrect.  
 Explanations may vary.  
 53.  $\begin{bmatrix} 23.94 & -7.56 & 28.98 \\ 21.66 & -6.84 & 26.22 \end{bmatrix}$   
 55.  $\begin{bmatrix} -23.94 & -26.72 \end{bmatrix}$   
 57.  $\begin{bmatrix} -79.59 \\ 39.21 \\ 10.08 \end{bmatrix}$

## 6.5 EXERCISES

1.  $\begin{bmatrix} 14 & -5 \\ 1 & 9 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 7 \\ 2 \end{bmatrix}$   
 3.  $\begin{bmatrix} 1 & 2 \\ 9 & -3 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} -6 \\ -14 \end{bmatrix}$

$$5. \begin{bmatrix} 3 & -7 & 1 \\ 1 & -1 & 0 \\ 0 & 8 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -4 \\ 2 \\ -3 \end{bmatrix}$$

$$7. \begin{bmatrix} 3 & -8 \\ 5 & 5 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \end{bmatrix}$$

$$9. \begin{bmatrix} 4 & -3 \\ 2 & -4 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} -9 \\ 13 \end{bmatrix}$$

$$11. \begin{bmatrix} 2 & -1 & 3 \\ -1 & 1 & 0 \\ 4 & -5 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 17 \\ -2 \end{bmatrix}$$

$$13. \begin{bmatrix} -\frac{1}{20} & -\frac{1}{5} \\ \frac{1}{4} & 0 \end{bmatrix}$$

$$15. \begin{bmatrix} -5 & -4 \\ 4 & 3 \end{bmatrix}$$

$$17. \begin{bmatrix} -5 & 0 \\ 2 & 2 \end{bmatrix}$$

19. Not invertible

$$21. \begin{bmatrix} 2 & 1 & -4 \\ -4 & -2 & -3 \\ -1 & -1 & -4 \end{bmatrix}$$

$$23. \begin{bmatrix} -1 & 2 & -1 \\ 0 & -1 & 1 \\ 0 & -4 & 3 \end{bmatrix}$$

$$25. \begin{bmatrix} -1 & -2 & 1 \\ -2 & 1 & -3 \\ 1 & 2 & 0 \end{bmatrix}$$

$$27. \begin{bmatrix} -2 & 1 & 1 \\ 2 & 0 & -1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$29. \begin{bmatrix} 2 & -1 & 2 \\ 0 & 1 & -1 \\ -3 & -2 & -4 \end{bmatrix}$$

31. No                    33. Yes

$$35. \text{No}                    37. \left( -2, -\frac{5}{2} \right)$$

$$39. \left\{ \left( \frac{3y-1}{2}, y \right) \mid y \in \mathbb{R} \right\}$$

41.  $(-2, 0)$             43.  $(8, -19)$

45. (0,5)      47. (-4,5,-1)  
 49. (-13,19,23); (0,0,-1); (1,-1,-1)  
 51. (1,-8,7); (3,1,1); (4,2,0)

53. 
$$\begin{bmatrix} \frac{-1}{4} & \frac{1}{10} \\ \frac{-1}{4} & \frac{3}{10} \end{bmatrix}$$

55. 
$$\begin{bmatrix} 0.053 & -0.258 \\ 0.113 & 0.076 \end{bmatrix}$$

57. 
$$\begin{bmatrix} 0.004 & -0.003 & 0.009 \\ 0 & 0.020 & 0.029 \\ 0.012 & 0.014 & 0.013 \end{bmatrix}$$

**6.6 EXERCISES**

1. a. 0.1 units agriculture,  
0.6 units manufacturing  
 b. 2.1 units agriculture,  
0.6 units manufacturing  
 c.  $\begin{bmatrix} 0.3 & -0.1 \\ -0.2 & 0.4 \end{bmatrix}, \begin{bmatrix} 4.0 & 1.0 \\ 2.0 & 3.0 \end{bmatrix}$   
 d.  $\begin{bmatrix} 37,000 \\ 31,000 \end{bmatrix}$

3. a. 0.1 units agriculture,  
0.1 units mining,  
0.1 units manufacturing

- b. 0.4 units agriculture,  
0.4 units mining,  
0.4 units manufacturing

c. 
$$\begin{bmatrix} 0.9 & -0.2 & -0.3 \\ -0.1 & 0.8 & -0.3 \\ -0.1 & -0.2 & 0.7 \end{bmatrix},$$

$$\begin{bmatrix} 1.25 & 0.5 & 0.75 \\ 0.25 & 1.5 & 0.75 \\ 0.25 & 0.5 & 1.75 \end{bmatrix}$$

d. 
$$\begin{bmatrix} 1700 \\ 2500 \\ 2100 \end{bmatrix}$$

5. 
$$\begin{bmatrix} 900 \\ 600 \end{bmatrix}$$
      7. 
$$\begin{bmatrix} 240 \\ 420 \\ 140 \end{bmatrix}$$

9. \$800 manufacturing, \$1400 agriculture  
 11. \$800 computer manufacturing,  
\$1600 automobile manufacturing

13. \$4750 museums, \$6875 theater,  
\$4875 sporting events

15. \$2375 curative, \$4125  
rehabilitative, \$2875 preventative

17. \$3125 manufacturing, \$2250  
agriculture, \$3375 health, \$3750  
energy

19. \$180 agriculture, \$80  
manufacturing, \$480 energy

21. a.  $x_1 = \frac{3}{8}x_2$

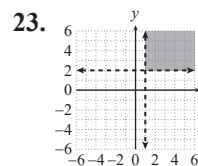
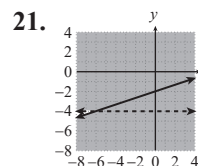
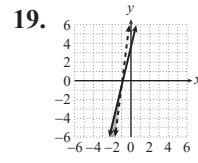
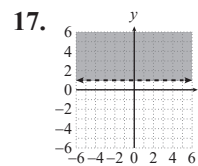
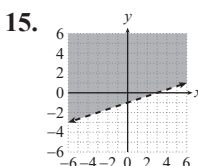
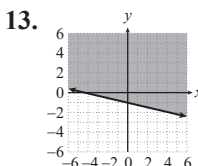
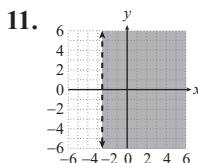
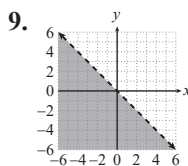
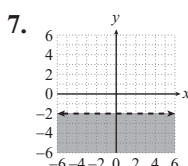
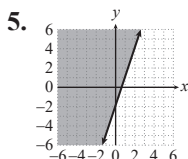
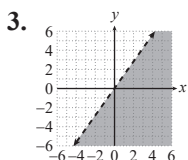
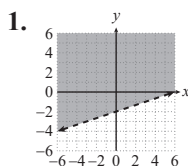
- b. Agriculture needs to  
produce \$3 for every \$8 of  
manufacturing produced.

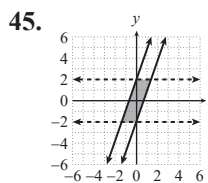
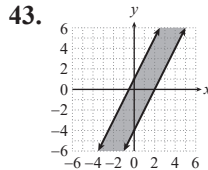
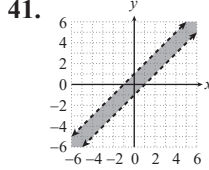
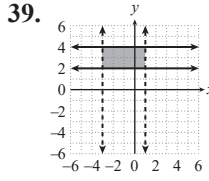
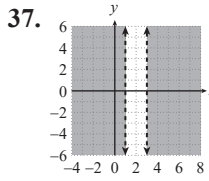
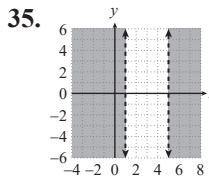
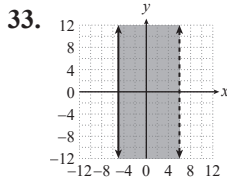
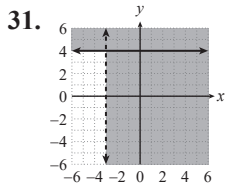
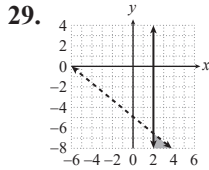
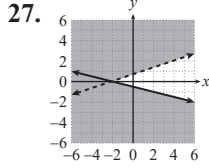
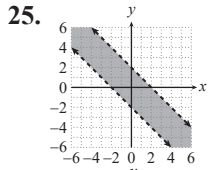
23. a.  $x_1 = \frac{22}{37}x_3, x_2 = \frac{43}{37}x_3$

- b. For every \$37 of energy  
produced, agriculture  
needs to produce \$22 and  
manufacturing needs to  
produce \$43.

**Chapter 7: Inequalities and Linear Programming**

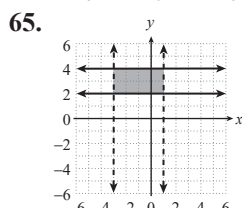
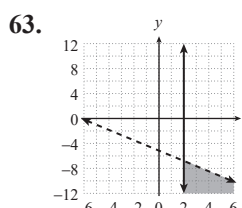
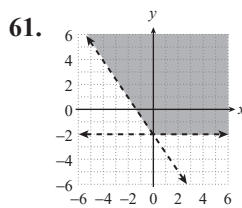
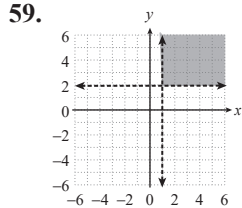
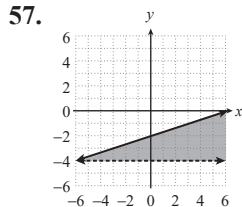
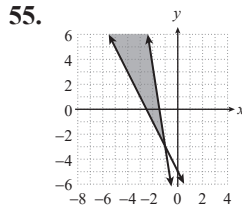
**7.1 EXERCISES**





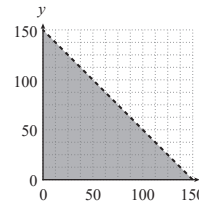
47. h                      49. b

51. g                      53. c



67.  $5.5x < 200$

69.  $x + y \leq 150$



**7.2 EXERCISES**

1. Min = 0 at (0, 0);

Max = 21 at (0, 7)

3. Min = 0 at (0, 0);

Max = 35 at (0, 7)

5. Min = 25 at (5, 0);

Max = 95 at (7, 10)

7. Min =  $\frac{40}{3}$  at  $(0, \frac{10}{3})$ ;

Max = 44 at (4, 5)

9. Min = 0 at (0, 0);

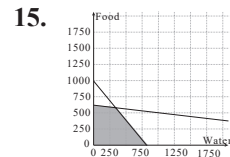
Max = 50 at (3, 4)

11. Min = 6 at (0, 6);

Max = 96 at (16, 0)

13. Min =  $\frac{172}{11}$  at  $(\frac{24}{11}, \frac{10}{11})$ ;

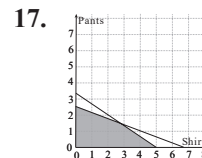
Max =  $\frac{400}{3}$  at  $(0, \frac{40}{3})$



$60x + 50y \leq 50,000$ ;

$x + 10y \leq 6000$ ;

$x \geq 0$ ;  $y \geq 0$



$12x + 32y \leq 80$ ;

$2x + 3y \leq 10$ ;

$x \geq 0$ ;  $y \geq 0$

19. Model X: 1000 units;

Model Y: 500 units;

Maximum profit: \$76,000

21. Ashley should buy 3 olive bundles and 2 cranberry bundles. The total cost to make the curtains is \$70.
23. Municipal bonds: \$20,000; Treasury bills: \$5000

**7.3 EXERCISES**

1. a.  $s_1, s_2$  basic;  $x_1, x_2$  nonbasic  
 b.  $(x_1, x_2, s_1, s_2, z) = (0, 0, 6, 4, 0)$   
 c. 3

$$\begin{array}{l}
 \text{d. } \left[ \begin{array}{cccc|c} x_1 & x_2 & s_1 & s_2 & z \\ \hline \boxed{3} & 1 & 1 & 0 & 0 & 6 \\ 1 & 2 & 0 & 1 & 0 & 4 \\ -7 & -5 & 0 & 0 & 1 & 0 \end{array} \right] \\
 \xrightarrow{\frac{1}{3}R_1} \\
 \xrightarrow{-R_1 + R_2} \\
 \xrightarrow{7R_1 + R_3} \\
 \left[ \begin{array}{cccc|c} x_1 & x_2 & s_1 & s_2 & z \\ \hline 1 & \frac{1}{3} & \frac{1}{3} & 0 & 0 & 2 \\ 0 & \frac{5}{3} & -\frac{1}{3} & 1 & 0 & 2 \\ 0 & -\frac{8}{3} & \frac{7}{3} & 0 & 1 & 14 \end{array} \right]
 \end{array}$$

3. a.  $x_2, s_3$  basic;  $x_1, s_1, s_2$  nonbasic  
 b.  $(x_1, x_2, s_1, s_2, s_3, z) = (0, 5, 0, 0, 3, 35)$   
 c. 3 (row 2, col 3)  
 d.

$$\begin{array}{l}
 \left[ \begin{array}{cccc|c} x_1 & x_2 & x_3 & s_1 & s_2 & z \\ \hline 1 & 1 & 1 & 1 & 0 & 0 & 5 \\ 3 & 0 & \boxed{3} & -1 & 1 & 0 & 3 \\ -3 & 0 & -11 & 7 & 0 & 1 & 35 \end{array} \right] \\
 \xrightarrow{\frac{1}{3}R_2} \\
 \xrightarrow{-R_2 + R_1} \\
 \xrightarrow{11R_2 + R_3} \\
 \left[ \begin{array}{cccc|c} x_1 & x_2 & x_3 & s_1 & s_2 & z \\ \hline 0 & 1 & 0 & \frac{4}{3} & -\frac{1}{3} & 0 & 4 \\ 1 & 0 & 1 & -\frac{1}{3} & \frac{1}{3} & 0 & 1 \\ 8 & 0 & 0 & \frac{10}{3} & \frac{11}{3} & 1 & 46 \end{array} \right]
 \end{array}$$

5. max of 38 at  $(x_1, x_2) = (4, 3)$   
 7. max of 16 at multiple points; answers vary: e.g.  $(x_1, x_2) = (0, 2)$  and  $(x_1, x_2) = \left(\frac{8}{5}, \frac{6}{5}\right)$   
 9. max of 48 at  $(x_1, x_2, x_3) = (3, 2, 7)$   
 11. max of 286 at  $(x_1, x_2, x_3) = (3, 40, 17)$

13. 70 drills, 30 tables saws; max of \$750  
 15. 16 pairs A, 8 pairs B; max of \$88  
 17. 50 Type A, 120 Type B; max of \$8,970,000 (26,250 worker-days of labor)  
 19. 25 one-bedroom, 50 two-bedroom, 25 three-bedroom; max of \$85,000

21. 20 bookshelves, 15 bed frames, 15 recliners; max of \$21,250  
 23. 20 newspaper, 14 radio; max of 300,000 women under 24  
 25. 30 male, 7 female; max of 37 rabbits  
 27. 3 onions, 3 turnips, 4 radishes; max of 10 plants  
 29. No; The line  $2x_1 + 5x_2 = 80$  doesn't form any boundary of the feasible region, and thus has no candidates for finding a maximum.

31. a. There is a negative entry in the bottom row and  $\frac{6840}{\frac{7}{18}} = 380$  is smaller than  $\frac{4800}{\frac{7}{6}} = 800$  and  $\frac{2700}{\frac{7}{6}} = 450$ .

- b. No; It appears the optimal feasible solution is  $(x_1, x_2, x_3, s_1, s_2, s_3, z) = (380, 0, 300, 0, 0, 0, 1146)$ ,

but  $f(380, 0, 300) = \frac{3}{2}(380) + \frac{6}{5}(0) + \frac{8}{5}(300) = 1050$  is not optimal.

- c. 2; Yes, the number of basic variables doesn't match the number of constraints.  
 d. Yes, performing  $R_2 + R_1$  will change row 1, column 5 from -1 to 0, and  $s_2$  will become a third basic variable. This yields our desired optimal feasible solution.

$$\begin{array}{l}
 \left[ \begin{array}{cccc|c} x_1 & x_2 & x_3 & s_1 & s_2 & s_3 & z \\ \hline 0 & 1 & 1 & 2 & -1 & 0 & 0 & 300 \\ 0 & \frac{2}{3} & 0 & -\frac{2}{3} & 1 & -\frac{1}{3} & 0 & 60 \\ 1 & -\frac{11}{18} & 0 & -\frac{8}{9} & 0 & \frac{7}{18} & 0 & 380 \\ \hline 0 & \frac{11}{20} & 0 & \frac{4}{5} & 0 & \frac{1}{20} & 1 & 1146 \end{array} \right] \\
 \xrightarrow{R_2 + R_1} \\
 \left[ \begin{array}{cccc|c} x_1 & x_2 & x_3 & s_1 & s_2 & s_3 & z \\ \hline 0 & \frac{5}{3} & 1 & \frac{4}{3} & 0 & -\frac{1}{3} & 0 & 360 \\ 0 & \frac{2}{3} & 0 & -\frac{2}{3} & 1 & -\frac{1}{3} & 0 & 60 \\ 0 & -\frac{11}{18} & 0 & -\frac{8}{9} & 0 & \frac{7}{18} & 0 & 380 \\ \hline 0 & \frac{11}{20} & 0 & \frac{4}{5} & 0 & \frac{1}{20} & 1 & 1146 \end{array} \right]
 \end{array}$$

**7.4 EXERCISES**

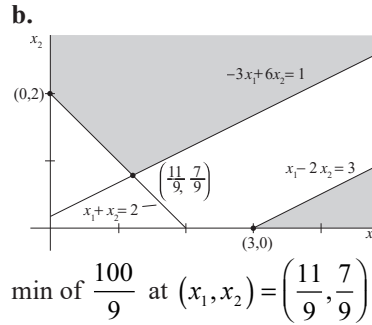
1.  $A^T = \begin{bmatrix} 2 & 4 \\ 3 & 6 \\ 7 & 2 \end{bmatrix}$

3.  $A^T = \begin{bmatrix} 1 & 6 & 7 & -1 \\ 3 & -5 & 2 & 0 \end{bmatrix}$

5. Maximize  $g(y_1, y_2) = 18y_1 + 15y_2$  subject to constraints  $\begin{cases} 3y_1 + 2y_2 \leq 7 \\ 5y_1 + 6y_2 \leq 2 \end{cases}$

7. Maximize  $g(y_1, y_2) = 16y_1 + 20y_2$  subject to constraints  $\begin{cases} 2y_1 + 5y_2 \leq 3 \\ 3y_1 \leq 1 \\ 4y_2 \leq 2 \end{cases}$ .

9. min of 5 at  $(x_1, x_2) = (0, 5)$
11. min of  $\frac{17}{3}$  at  
 $(x_1, x_2, x_3) = \left(5, \frac{1}{3}, 0\right)$
13. min of 31 at  
 $(x_1, x_2, x_3) = \left(\frac{3}{8}, \frac{15}{8}, \frac{11}{8}\right)$
15. min of 33 at  $(x_1, x_2, x_3) = (0, 11, 0)$
17. 25 hours plant A, 10 hours plant B; min of \$45,000
19. 1 bottle Drink I, 2 bottles Drink II; min of \$32
21. 7 days refinery A, 6 days refinery B, 8 days refinery C; min of \$675,000
23. 7 grams food I, 4.5 grams food II; min of 20.5 units of ingredient C
25. 55 minutes radio, 35 minutes television; min of \$19,875
27. 2 servings meal I, 1 serving meal II, 3 servings meal III; min of 1.9 ounces of detrimental substance
29. a. The dual maximization problem has no solution.



### 7.5 EXERCISES

1. 
$$\begin{cases} 5x_1 + x_2 + s_1 = 15 \\ 3x_1 + 2x_2 - s_2 = 7 \end{cases}$$

3. 
$$\begin{cases} 8x_1 + 3x_2 - x_3 - s_2 = 10 \\ 6x_2 - x_3 - s_3 = 7 \\ x_1 + x_2 + x_3 + s_1 = 8 \end{cases}$$

5. 
$$\begin{cases} 4x_1 - x_3 - s_3 = 9 \\ x_2 + 2x_3 + s_1 = 13 \\ 5x_1 - x_2 + 4x_3 - s_4 = 14 \\ 3x_1 + x_2 + x_3 + s_2 = 17 \end{cases}$$

7. maximize  
 $-f(x_1, x_2, x_3) = -4x_1 - 7x_2 - 9x_3;$   
 constraints:  

$$\begin{cases} x_1 + x_2 + x_3 + s_1 = 9 \\ x_1 - 3x_3 + s_2 = -6 \\ -5x_1 + x_2 + x_3 + s_3 = -7 \end{cases}$$

9. maximize  
 $-f(x_1, x_2, x_3) = -4x_1 - 7x_2 - 9x_3;$   
 constraints:  

$$\begin{cases} x_1 + x_2 + x_3 + s_1 = 9 \\ -x_1 + 3x_3 - s_2 + a_1 = 6 \\ 5x_1 - x_2 - x_3 - s_3 + a_2 = 7 \end{cases};$$
  
 $z = -4x_1 - 7x_2 - 9x_3 - Ma_1 - Ma_2$

11. min of 4 at  $(x_1, x_2) = (1, 0)$
13. max of 20 at  $(x_1, x_2, x_3) = (0, 5, 5)$
15. min of 20 at  $(x_1, x_2, x_3) = (1, 2, 3)$
17. max of 56 at  $(x_1, x_2, x_3) = (8, 2, 0)$
19. 150 Charlotte to Raleigh, 250 Charlotte to Spartanburg, 200 Charleston to Raleigh, 0 Charleston to Spartanburg; max of \$3150
21. 400 factory A to dealership II, 300 factory B to dealership I, 0 factory A to dealership I, 0 factory B to dealership II; min of \$22,500
23. 2.5 million gallons at plants I and III, none at plant II; min of \$275,000
25. 28 television ads, 5 newspaper ads; max of 57 million voters
27. 30 Tropical Paradise, 45 Arctic Chill, 30 Paradise Blast; max of \$54
29. 52 gallons mix I, 8 gallons mix II, 20 gallons mix III; min of \$4080
31. max of 21 at multiple points, e.g.  
 $(x_1, x_2) = \left(0, \frac{7}{3}\right)$  and  
 $(x_1, x_2) = \left(\frac{8}{5}, \frac{9}{5}\right)$
33. a. min of 14 at  $(x_1, x_2) = (1, 3)$   
 b. No; the condition  $3x_1 + x_2 = 6$  is more restrictive than  $3x_1 + x_2 \geq 6$ .

## Chapter 8: Probability

### 8.1 EXERCISES

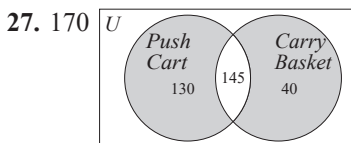
1. False; the set may be an infinite set.
3. True                      5. True
7. True                        9. True
11.  $B = \{\text{Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, North Carolina}\}$
13. Answers will vary.
15.  $F = \{\text{Monday, Tuesday, Wednesday, Thursday, Friday}\}$
17.  $H = \{x \mid x \in \mathbb{N}, x \leq 50\}$
19.  $K = \{x \mid x \in U, x \text{ is an athlete}\}$
21.  $K$  is the set of US paper currency that is at most \$100.
23.  $N$  is the set of months beginning with the letter J.
25.  $B = \{3, 6, 9, 12, 15\}$
27.  $D = \{\text{Wyoming, Nebraska, Kansas, New Mexico, Oklahoma, Utah, Arizona}\}$

29. Yes; they have the same elements, just in a different order.
31. Yes;  $P$ ,  $R$ , and  $S$  are all equivalent. They all contain 5 elements.  $Q$  is not equivalent to any of them.
33. No; they have different elements.
35.  $B$  is equivalent to  $C$  since they each have 5 elements.  $A$  and  $D$  are not equivalent to the other sets.
37.  $|X| = 9$
39.  $|Y| = 43$ , as of printing
41.  $A' = \{c, d, f, g, h, i, j, l, m, n, o, p, q, r, u, v, w, x, y, z\}$
43.  $A' = \{c, d, f, g, h, i, j, l, m, n, o, p, q, r, u, v, w, x, y, z, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z\}$
45. 4
47. 6
49. 15
51.  $Y = \{CHN, SWE, ITA, FRA, GER, GBR, RUS, GDR\}$
53.  $G = \{CHN, ITA, FRA, GER, GBR, URS, USA\}$
55. No; they have different cardinal numbers, that is, a different number of elements.
57. Answers will vary.
59. Answers will vary. Examples include  $U = \{\pi\}$ ;  $U = \mathbb{R}$ ;  $U = \{x \mid x \in \mathbb{R}, x > 0\}$

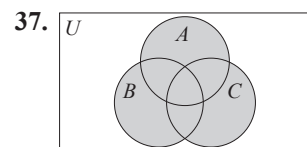
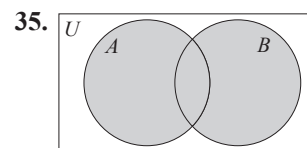
### 8.2 EXERCISES

- $\{1, 2, 3, 4, 5, 6, 7, 8, 10, 12\}$
- $\emptyset$  or  $\{\}$
- $(A \cup B)' = \{9, 11, 13, 14, 15, 16, 17, 18, 19, 20\}$  and  $A' = \{9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20\}$  and  $B' = \{1, 3, 5, 7, 9, 11, 13, 14, 15, 16, 17, 18, 19, 20\}$ .  
So  $A' \cap B' = \{9, 11, 13, 14, 15, 16, 17, 18, 19, 20\}$ .
- $\{n, u, m, b, e, r, s, l\}$
- 3

11.  $A \cap B = \{r, u, e\}$ ,  $(A \cap B)' = \{a, b, c, d, f, g, h, i, j, k, l, m, n, o, p, q, s, t, v, w, x, y, z\}$ ,  $A' = \{a, c, d, f, g, h, i, j, k, l, o, p, q, t, v, w, x, y, z\}$ ,  $B' = \{a, b, c, d, f, g, h, i, j, k, m, n, o, p, q, s, t, v, w, x, y, z\}$ , so  $A' \cup B' = \{a, b, c, d, f, g, h, i, j, k, l, m, n, o, p, q, s, t, v, w, x, y, z\}$ .
13.  $\{C, E\}$
15.  $A \cup B = \{I, C, E, U, B\}$ ,  
 $(A \cup B)' = \{A, D, F, G, H, J, K, L, M, N, O, P, Q, R, S, T, V, W, X, Y, Z\}$ ,  $A' = \{A, B, D, F, G, H, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z\}$ ,  $B' = \{A, D, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, V, W, X, Y, Z\}$ , and  $A' \cap B' = \{A, D, F, G, H, J, K, L, M, N, O, P, Q, R, S, T, V, W, X, Y, Z\}$
17.  $\{A, C, D, F, O, P, R, T, U\}$
19. 4
21.  $A \cap B = \{C, O, R, T\}$ ,  
 $(A \cap B)' = \{A, B, D, E, F, G, H, I, J, K, L, M, N, P, Q, S, U, V, W, X, Y, Z\}$ ,  $A' = \{B, D, E, G, H, I, J, K, L, M, N, P, Q, S, U, V, W, X, Y, Z\}$ ,  $B' = \{A, B, E, F, G, H, I, J, K, L, M, N, Q, S, V, W, X, Y, Z\}$ , and  $A' \cup B' = \{A, B, D, E, F, G, H, I, J, K, L, M, N, P, Q, S, U, V, W, X, Y, Z\}$
23.  $\{g, a, t, o, r, b, i, e\}$
25.  $M \cup K = \{b, r, i, d, g, e, a, l, s, t\}$ ,  
 $(M \cup K)' = \{c, f, h, j, k, m, n, o, p, q, u, v, w, x, y, z\}$ ,  $M' = \{a, c, f, h, j, k, l, m, n, o, p, q, s, t, u, v, w, x, y, z\}$ ,  $K' = \{c, d, f, g, h, j, k, m, n, o, p, q, u, v, w, x, y, z\}$ , and  $M' \cap K' = \{c, f, h, j, k, m, n, o, p, q, u, v, w, x, y, z\}$ .



29. Will, David, Kim, Barbara, Alden, Morgan, Ali, Holly, Jessica, Jeff, Kent
31. 11                      33. 39



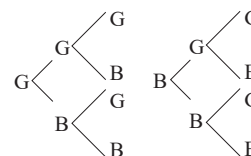
39.  $A \cap B'$

### 8.3 EXERCISES

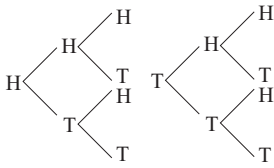
- $\{H1, H2, H3, H4, H5, H6, T1, T2, T3, T4, T5, T6\}$
- $\{BC, BG, BY, BR, CB, CG, CY, CR, GB, GC, GY, GR, YB, YC, YG, YR, RB, RC, RG, RY\}$
- Empirical      7. Classical
- a.  $\frac{8}{64} = 0.125$
- b.  $\frac{17}{64} = 0.265625$
- c.  $\frac{49}{64} = 0.765625$
- $\frac{33}{84} \approx 0.392857$
- $\frac{1}{235} \approx 0.004255$
- $\frac{18}{38} \approx 0.473684$
- $\frac{4}{52} \approx 0.076923$
- $\frac{1}{16} = 0.0625$
- $\frac{10}{69} \approx 0.144928$

### 8.4 EXERCISES

- $\{GGG, GGB, GBG, GBB, BGG, BGB, BBG, BBB\}$



3. {HHH, HHT, HTH, HTT, THH, THT, TTH, TTT}



5. 120                    7. 56  
 9. 1                      11. 10  
 13. 46                    15. 840  
 17. 24                    19. 30  
 21.  $\frac{1}{2}$                     23. 98

25.  $10 \cdot 10 \cdot 10 = 1000$   
 27.  $26 + 10 = 36$ ,  
 so  $36 \cdot 36 \cdot 36 \cdot 36 \cdot 36 \cdot 36$   
 $= 2,176,782,336$

29. 144 possibilities  
 31.  $3^{11} = 177,147$   
 33.  $10^7 = 10,000,000$   
 35.  $39 \cdot 10 \cdot 8 = 3120$   
 37. Combination;  
 ${}_{120}C_5 = 190,578,024$  ways  
 39. Combination;  ${}_{29}C_3 = 3654$  ways  
 41. Permutation;  ${}_{18}P_3 = 4896$  ways  
 43. Permutation;

$$\frac{10!}{3!3!1!2!1!} = 50,400 \text{ ways}$$

45. c.  
 47. Answers will vary; should be  
 (number of pants) ·  
 (number of shirts) ·  
 (number of pairs of shoes)

### 8.5 EXERCISES

- The set of even numbers larger than 0.
- The complement consists of players aged 8 or 9, so there are nine players in the complement of  $A$ .
- All employees who have worked there for less than or equal to five years.
- $\frac{5}{{}_{10}C_2} = \frac{5}{45} \approx 0.111111$

9. a.  ${}_{16}C_3 = 560$   
 b.  $\frac{1}{560} \approx 0.001786$

11. a.  $4! = 24$   
 b.  $\frac{2 \cdot 3!}{24} = \frac{12}{24} = 0.5$

13. a.  ${}_{52}C_5 = 2,598,960$   
 b.  $\frac{4}{2,598,960} \approx 0.000002$

15. a.  $10^4 = 10,000$   
 b.  ${}_{10}P_4 = 10 \cdot 9 \cdot 8 \cdot 7 = 5040$

- c.  $\frac{1}{4!} = \frac{1}{24} \approx 0.041667$   
 d.  $\frac{1}{3 \cdot \left(\frac{4!}{2!1!1!}\right)} = \frac{1}{36} \approx 0.027778$

e. Repeat a digit

17.  $\frac{3}{1000} = 0.003$

19.  $\frac{1}{26 \cdot 25 \cdot 24} = \frac{1}{15,600} \approx 0.000064$

21.  $\frac{{}_4C_2}{{}_6C_2} = \frac{6}{15} = 0.4$

23.  $1 - \frac{3}{18} \approx 0.833333$

25. a.  $\frac{871}{1502} \approx 0.579893$

- b.  $1 - \frac{871}{1502} \approx 0.420107$

27.  $1 - \frac{1}{2^5} = \frac{31}{32} = 0.96875$

### 8.6 EXERCISES

- These are independent events because they are choices by three random people.
- No, the choice of the first person changes the probability of the second person's gender.
- No, whose card is picked first affects the probabilities of the next pick.
- $\frac{8}{36} = \frac{2}{9} \approx 0.222222$

9.  $\frac{8}{52} = \frac{2}{13} \approx 0.153846$

11. a.  $\frac{102}{137} \approx 0.744526$

- b.  $\frac{76}{137} \approx 0.554745$

13. 0.46

15.  $\frac{8}{11} \approx 0.727273$

17. a.  $\frac{21}{113} \approx 0.185841$

- b.  $\frac{76}{113} \approx 0.672566$

- c.  $\frac{40}{113} \approx 0.353982$

19.  $\frac{6}{11} \approx 0.545455$

21. 0.312

23.  $\frac{13}{52} \cdot \frac{4}{52} = \frac{52}{2704} \approx 0.019231$

25.  $\frac{6}{10} = \frac{3}{5} = 0.6$

27.  $\frac{3}{51} \approx 0.058824$

29. 0.666667

31.  $\frac{16}{34} = \frac{8}{17} \approx 0.470588$

33.  $\frac{{}_{18}C_5}{{}_{20}C_5} = \frac{8568}{15,504} \approx 0.552632$

### 8.7 EXERCISES

- Expected value = 2.15
- Expected value = 16
- 0.65 times per week
- Expected winnings =  $-\$0.03$
- a. 1 ticket:  $-\$8$ ; 3 tickets:  $-\$19$ ;  
5 tickets:  $-\$30$   
b. 1 ticket
- 32.25%
- a. 0    b. 0
- $\frac{1}{7}$                       17.  $\frac{2}{5}$
- $\frac{5}{7}$
- a. 0.822    b.  $\$80.24$

## Chapter 9: Statistics

### 9.1 EXERCISES

1. census
3. population, population parameters
5. Sample statistic
7. Sample statistic
9. Population: cancer patients;  
Sample: 675 cancer patients;  
Sample statistics: 76% and 63%
11. Population: middle-aged women;  
Sample: 36,000 health records of women; Sample statistics: 18% and 11%; Population parameter: 40%
13. Systematic sampling
15. Cluster sampling
17. Convenience sampling
19. Random sampling
21. Random sample, since there are not clear divisions in the sample group of 1200 patients. Possible biases include age, race, and stage of development of the skin disease in the patients. Answers will vary.
23. Convenience sample, since the population is all children with autism, this is a very large group that may be difficult to study. It may be best to start with a convenience sample to get an idea of where to start. A possible bias to consider is that the effects may be different on children at different levels of functionality, so it may be best to make sure that a range of children are represented. Answers will vary.
25. Answers will vary. No, it is not likely to include all of the American public, since it will not include the section of the public who do not have internet access, and the only people who would respond are people who frequent those news outlet sites. Because some news outlets may have a

slight bias one way or the other, each may draw only a certain demographic.

27. Answers will vary. For example, income level, health of residents, happiness of residents, average annual temperature, number of activities in the area.

### 9.2 EXERCISES

1. histogram      3. line
5. frequency distribution
7. a. 6    b. 1 kg  
c. 2.00 kg    d. 4.99 kg  
e. 89/194 or  $\approx 45.9\%$

9. a.–b.

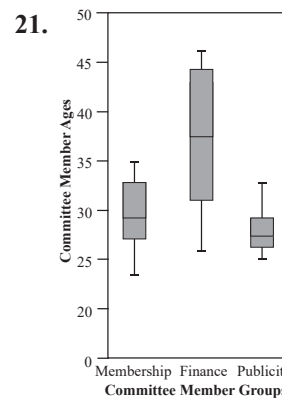
Class	Freq.	Rel. Freq.
0–9	0	0%
10–19	6	17.1%
20–29	8	22.9%
30–39	5	14.3%
40–49	4	11.4%
50–59	3	8.6%
60–69	5	14.3%
70–79	4	11.4%

- c. 11.4%    d. 0%
- e. 20–29 calls
11. a. 2  
b. The western US
13. a. Generally decreasing with brief periods of increase.  
b. June 2011; 9.2%  
c. January 2013; 7.7%  
d. Answers might include making it clearer that these are percentages and that the  $x$ -axis is not marked very clearly.
15. a. Approximately 6 hours  
b. Approximately 7 hours  
c. There is essentially no difference in the number of hours wives spend sleeping.  
d. A pair of side-by-side bar graphs: one for husbands and one for wives.

### 9.3 EXERCISES

1. Mean: 24; median: 25; mode: 22, 27; range: 17; standard deviation: 4.8; bimodal
3. Mean: 34.3; median: 35; mode: 26; range: 25; standard deviation: 9.0; unimodal
5. Mean:  $-1.8$ ; median:  $-3$ ; mode:  $-7, -3, 3$ ; range: 18; standard deviation: 5.9; multimodal
7. Mean: 147.3 minutes; median: 149 minutes; mode: no mode; range: 31 minutes; standard deviation: 9.8 minutes
9. Mode      11. Mode
13. 86
15. a. 95%    b. 16%    c. 50%
17. Yes
19. a. Min: 35;  $Q_1$ : 37;  $Q_2$ : 38;  $Q_3$ : 40; Max: 42

b. 38.5



- a. Finance Committee
- b. Publicity Committee
- c. Publicity Committee
23. No, you should not operate with means. We cannot assume that all five classes are the same size. For instance, suppose one section has 100 students with a mean of 72 and another section has only 11 students, but with a mean of 79. We cannot give equal emphasis to the two means. You will not get an accurate answer.

25. No, standard deviations cannot be negative values since they describe a distance.
27. Answers will vary. Possible examples: large variation: salaries of all employees of a Fortune 500 company; small variation: densities of water from different sources.
29. Yes, the five-number summary can be put back together in numerical order: 9, 11, 13.5, 17.5, 19. So,  $Q_1 = 11$ .
31. No, percentiles give the relative position in terms of percentages. Without knowing more information about the size of the sample, we cannot compute the size of the sample.

### 9.4 EXERCISES

7. a. 5   b. 45   c. 15   d. 1
9. a.  $E(X) = 0.9$    b.  $\sigma = 0.9$   
 c.  $P(X = 2) = 0.1722$   
 d.  $P(X \leq 3) = 0.9917$   
 e.  $P(X \geq 2) = 0.2252$   
 f.  $P(X < 5) = 0.9991$
11. a. Binomial distribution with  $n = 10$  and  $p = 0.10$   
 b.  $E(X) = 1$    c.  $\sigma = 0.9487$

- d.  $P(X = 1) = 0.3874$   
 e.  $P(X = 5) = 0.0015$   
 f.  $P(X \geq 3) = 0.0702$
13. a. Binomial distribution with  $n = 7$  and  $p = 0.1$   
 b.  $P(X = 0) = 0.4783$   
 There is a 47.83% chance that none of the plants will strike.  
 $P(X = 4) = 0.0026$   
 There is a 0.26% chance that exactly 4 of the plants will strike.  
 $P(X = 7) = 0$   
 There is a negligible chance that all 7 plants will strike.
- c.  $E(X) = 0.7$   
 d.  $\sigma = 0.794$ . The standard deviation is larger than the expected value. The standard deviation is expressed as the number of plants that strike. Answers may vary.
15. a.  $P(X = 2) = 0.375$   
 b.  $P(X = 4) = 0.0625$
17. a.  $P(X \leq 1) = 0.8290$   
 b.  $E(X) = 0.75$
19. a.  $\frac{2}{9} = 0.2222$   
 b.  $P(X = 5) = 0.0389$   
 c.  $P(X = 0) = 0.0810$   
 d.  $E(X) = 2.2222$ ,  
 $\sigma^2 = 1.7284$

### 9.5 EXERCISES

1. a.  $z = 0.55$    b.  $z = -1.73$   
 c.  $z = 0.09$
3. a.  $z = -1$    b.  $z = 0.5$   
 c.  $z = -3.17$
5. -0.45   7. 0.41
9. a.  $z = -0.87$    b.  $\mu = 277.12$   
 c.  $x = 130.30$    d.  $\sigma = 8.99$
11. 92.79%   13. 1.32%
15. 15.15%   17. 99.90%
19. 50.00%   21. 95%
23. 28.64%   25. 27.13%
27. 33.81%   29. 98.80%
31. Her second race
33. a. 5.16%   b. 95.76%  
 c. 99.94%   d. 88.88%
35. 1.29
37.  $Q_1: -0.67$ ;  $Q_2: 0$ ;  $Q_3: 0.67$

### 9.6 EXERCISES

5. Conditions are not met;  $np = 1.5 < 5$ .
7. a. 9   b. 2.7659  
 c. 0.5714   d. 0.0000  
 e. 0.9390
9. a. 60   b. 7.6681  
 c. 0.0001   d. 0.9924  
 e. 0.1075

## Chapter 10: Limits and the Derivative

### 10.1 EXERCISES

1.  $\lim = 14$

$x$	$y$
6.5	13.5
6.9	13.9
6.99	13.99
6.999	13.999

3.  $\lim = 0$

$x$	$y$
3.5	0.25
3.1	0.01
3.01	0.0001
3.001	0.000001

5.  $\lim = 10$

$a$	$y$
1.5	113.33
1.1	15.94
1.01	10.46
1.001	10.045

7. a.  $a = 2$    b.  $\lim = 0.25$
9. a.  $a = \pi$    b. No limit

11. a.  $-2, -1.84, -1.36, -1.19, -1.0199, -1.001999$   
 b.  $-1$
13. a.  $7, 8.76, 10.84, 11.41, 11.9401, 11.994001$   
 b.  $12$
15. a.  $3, 4\bar{3}, 11, 21, 201, 2001$   
 b.  $+\infty$
17. a.  $0.2, 0.217, 0.238, 0.244, 0.249, 0.2499$   
 b.  $0.25$
19.  $3$                       21.  $0$
23.  $2$                       25.  $-\infty$
27.  $2$                       29.  $2$
31.  $0$                       33.  $+\infty$
35.  $1$                       37.  $5$
39.  $-17$                     41.  $3$
43.  $0$                       45.  $-24$
47.  $-\infty$                     49.  $+\infty$
51.  $\frac{1}{4}$                       53.  $-\frac{1}{4}$
55. a.  $11$     b.  $11$
57. a.  $8$     b.  $9$
59. a.  $3$     b.  $3$   
 c.  $3$     d.  $+\infty$
61. yes

### 10.2 EXERCISES

1. a.  $0$     b.  $0$     c.  $0$     d.  $2$
3. a.  $-\infty$     b.  $1$     c.  $1$     d.  $1$
5. a.  $5$     b.  $6$   
 c. does not exist  
 d.  $2$     e.  $2$     f.  $2$
7. a.  $+\infty$     b.  $-\infty$     c.  $2$     d.  $0$
9. a.  $+\infty$     b.  $3$   
 c. does not exist    d.  $0$
11.  $11$
13. limit does not exist
15.  $-3$
17. a.  $480$     b.  $480$     c.  $480$

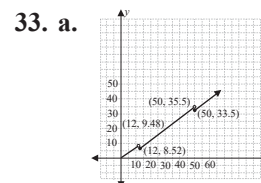
### 10.3 EXERCISES

1.  $6$                       3.  $10$
5.  $+\infty$                     7.  $\frac{6}{7}$
9.  $\frac{1}{2}$                       11.  $0$
13.  $-\infty$                     15.  $\frac{3}{4}$
17.  $-\infty$                     19.  $8$
21.  $3$                       23.  $-2$
25. a.  $\frac{1}{4}$     b.  $6$
27.  $1$
29. a.  $-3$     b.  $-3$     c.  $-3$     d.  $-2$
31. a.  $3$     b.  $3$     c.  $3$     d.  $5$
33. a.  $\$11.88$     b.  $\$11.88$   
 c.  $\$11.88$
35.  $\$73$

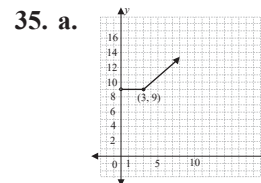
### 10.4 EXERCISES

1. a.  $2$     b.  $2$   
 c. Does not exist  
 d.  $f(x)$  is not continuous at  $x = 3$  because it has a removable discontinuity ( $f(3)$  is undefined).
3. a.  $-2$     b.  $-2$     c.  $-2$   
 d. Yes, because the limit exists, the function exists, and the limit equals the value of the function at  $x = 0$ , i.e.,  
 $\lim_{x \rightarrow 0} f(x) = f(0)$ .
5. a.  $-1$     b.  $+\infty$     c.  $-1$   
 d.  $f(x)$  is not continuous at  $x = 4$ , as the limit doesn't exist at that point.
7. a. No,  $f(x)$  is discontinuous at  $x = -1$ , because  
 $\lim_{x \rightarrow -1} f(x) \neq f(-1)$ .  
 b.  $f(x)$  is continuous at  $x = 3$ , as  
 $\lim_{x \rightarrow 3} f(x) = f(3) = 7$ .
9. At  $x = -3$ ,  $f(x)$  is discontinuous; it has a removable discontinuity.
11. At  $x = 0$ ,  $f(x)$  is discontinuous; it has a jump discontinuity.
13.  $f(x)$  is continuous at  $x = 1$ .

15.  $f(x)$  is discontinuous at  $x = 2$ .
17.  $f(x)$  is continuous at  $x = 1$ .
19.  $f(x)$  is discontinuous at  $x = 0$ .
21. No points of discontinuity
23.  $f(x)$  is discontinuous at  $x = -3$ ; it has an infinite discontinuity.
25.  $f(x)$  is discontinuous at  $x = 3$ ; it has an infinite discontinuity.  
 $f(x)$  is discontinuous at  $x = -3$ ; it has an infinite discontinuity.
27. No points of discontinuity
29.  $k = 2$                     31.  $k = 4$



- b.  $C$  is discontinuous at  $x = 12$  and at  $x = 50$ . These are jump discontinuities.



- b.  $C(x)$  is continuous for all  $x > 0$ .

### 10.5 EXERCISES

1.  $-1$                       3.  $5$
5.  $8$                       7.  $0.1333$
9.  $0.387$

### 10.6 EXERCISES

1.  $f'(15) = 1$             3. 12:00 p.m.
5.  $f(3) = 14$ : 14 is the value of the function at the point  $x = 3$ .  
 $f'(3) = 7$ : 7 is the slope of the tangent line at  $x = 3$ .
7.  $f'(s)$  is the rate of spending per customer for  $s$  customers.
9.  $f'(x)$  is the rate of change of cost per toaster.
11. The acceleration (or deceleration) of a race car after  $t$  seconds

13. The velocity of the rocket in  $x$  seconds
15.  $f'(t)$  is the rate of change of cost in dollars per year at  $t$  years since 1980.

17. a.  $f(500) = 2000$  means 500 man-hours are required to produce 2000 units.  
 $f'(500) = 3$ ; 3 more man-hours per unit are required if we increase  $x$  from 500 to 501.

b.  $f(501) = 2003$

19. a.  $f'(x)$  is negative. As  $x$  increases,  $f(x)$  decreases.
- b.  $f'(3) = -2500$  means  $f(x)$  is changing at the rate \$2500/year; i.e., the car decreases \$2500 in value if  $x$  increased from 3 years to 4 years of age.

21.  $f(3) = 4$  grams means at the time of 3 weeks after discovery there are 4 grams of cancerous tumor.  
 $f'(3) = 0.4$  grams/week at 3 weeks, the rate of change in weight of the tumor is 0.4 grams per week.

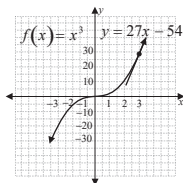
23. a.  $f(20) = 4.25$ ; it represents the average number of children per woman in 1990.

- b.  $f'(20) = -0.11$ ; it represents a decrease in the average number of children per woman in the year 1990.

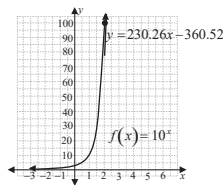
25. a.  $f(30) = 16.57$ ; it represents the yearly birth rate per 1000 people in 1994.

- b.  $f'(30) = -0.641$ ; it represents a decrease in the yearly birth rate per 1000 people in the year 1994.

27. Slope = 27



29. Slope =  $100 \ln(10) \approx 230.26$



31.

$a$	$f(a)$	$f'(a)$
-1	-1	3
0	0	0
1	1	3
2	8	12
3	27	27
4	64	48

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

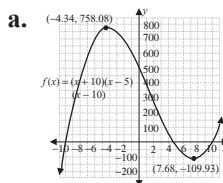
33.

$x$	$y$	y-intercept of the tangent line
-1	1	-1
0	0	0
1	1	-1
2	4	-4
3	9	-9
4	16	-16

Tangents at  $x = +a$  and  $x = -a$  have the same y-intercept.

35.  $\left(\frac{1}{4}, \frac{1}{2}\right)$

37. Window  $[-5, 8]$  by  $[-110, 800]$



b.  $f'(2) = -108$

39.  $f(x) = 2x^2$ ;  $f'(x) = 4x$

$x$	$f(x)$	$f'(x)$
-3	18	-12
-2	8	-8
-1	2	-4
0	0	0
1	2	4
2	8	8
3	18	12

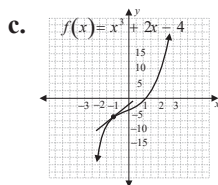
### 10.7 EXERCISES

1. 0                      3. 7
5.  $8x$                       7.  $-\frac{7}{x^2}$
9.  $-\frac{3}{2x^4}$                       11.  $\frac{3}{2\sqrt{x}}$
13.  $2.3t^{1.3}$                       15.  $2.4x^{-0.2}$
17.  $-\frac{1}{2}u^{-\frac{3}{2}}$                       19.  $-\frac{15}{4}x^{-\frac{1}{4}}$

### 10.8 EXERCISES

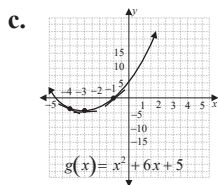
1.  $3x^2 - 7$                       3.  $0.6x - 4$
5.  $3x^2 - 12x + 5$                       7.  $3x^{\frac{1}{2}} + 2x^{-\frac{1}{2}}$
9.  $-t^{-\frac{3}{2}} + \frac{1}{2}t^{-\frac{1}{2}} + 1$
11.  $y = 2x^2 - x - 3$ ,  
 $y' = 4x - 1$
13.  $f(v) = v^{\frac{7}{2}} + 2v^{\frac{5}{2}} - v^{\frac{3}{2}}$ ,  
 $f'(v) = \frac{7}{2}v^{\frac{5}{2}} + 5v^{\frac{3}{2}} - \frac{3}{2}v^{\frac{1}{2}}$
15.  $f(x) = x^2 + 5x$ ,  
 $f'(x) = 2x + 5$
17.  $g(t) = \sqrt{t} - \frac{2}{\sqrt{t}}$ ,  
 $g'(t) = \frac{1}{2}t^{-\frac{1}{2}} + t^{-\frac{3}{2}}$
19.  $g(x) = 4\sqrt{x} + 5 - \frac{1}{\sqrt{x}}$ ,  
 $g'(x) = 2x^{-\frac{1}{2}} + \frac{1}{2}x^{-\frac{3}{2}}$

21. a.  $m = 5$  b.  $y = 5x - 2$



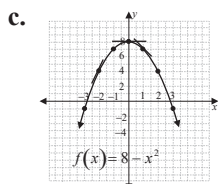
23. a.  $m = 4, m = 0, m = -2$

b.  $y = 4x + 4, y = -4,$   
 $y = -2x - 11$



25. a.  $m = 4, m = 0, m = -2$

b.  $y = 4x + 12, y = 8,$   
 $y = -2x + 9$



27. a. 192 ft/sec b. 64 ft/sec

c. 6 sec

29. a. 482 people/year

b. 488 people/year

31. a. 51.67 barrels

b. 7.13 barrels/hr

c. 7.09 barrels/hr

33. a. 10 hours

b. -1.3 charge units/hr

c. -0.9 charge units/hr

35. a. 5.585 b. 2.015

c. -0.187 births per woman per year

37. a. 7.06% b. 18.82%

c. 0.25% per year

39. a. 13.62 deaths/1000 people

b. -0.37 deaths/1000 people per year

c. 5.18 deaths/1000 people

d. 2008

41. a.  $f(30) = 2.66$ . This is the number of births per woman in the year 2000.

b.  $f'(30) = -0.046$ . The number of births per woman was decreasing by 0.046 births per woman in 2000.

### 10.9 EXERCISES

1.  $\bar{C}(x) = \frac{220}{x} + 0.4$

3.  $D(x) = 3; R(x) = 3x$

5.  $C(x) = 1.15x + 50$

7.  $P(x) = 0.75x + 25$

9. a.  $\bar{C}(x) = \frac{100}{x} + 150$

b.  $D(x) = 450$

c.  $R(x) = 450x$

d.  $P(x) = 300x - 100$

11. a.  $C'(x) = -0.6 - 0.03x^{-0.4}$

b.  $S'(x) = 1.6 + 0.03x^{-0.4}$

13. a.  $\bar{C}(x) = \frac{30}{x} + 2 + 0.003x$

b.  $\bar{C}'(x) = -\frac{30}{x^2} + 0.003$

c.  $x = 100$

15. a.  $C(10) = 2705, C(20) = 3060,$   
 $C(30) = 3465$

b.  $C' = 28 + 0.5x$

c.  $C'(10) = 33, C'(20) = 38,$

$C'(30) = 43$

d.  $\bar{C}(x) = \frac{2400}{x} + 28 + 0.25x,$

$\bar{C}'(x) = -2400x^{-2} + 0.25$

e.  $\bar{C}'(10) = -23.75,$

$\bar{C}'(20) = -5.75,$

$\bar{C}'(30) = -2.42$

17. a.  $C(4) = 92, C(6) = 102,$   
 $C(9) = 109.5$

b.  $C'(x) = 10 - x$

c.  $C'(4) = 6, C'(6) = 4, C'(9) = 1$

d.  $\bar{C}(x) = \frac{60}{x} + 10 - 0.5x$

e.  $\bar{C}'(4) = -4.25, \bar{C}'(6) = -2.17,$

19. a.  $P(x) = -0.03x^2 + 60x - 10,800$

b.  $P(200) = \$0, P(400) = \$8400,$   
 $P(600) = \$14,400$

c.  $P'(x) = -0.06x + 60$

d.  $P'(200) = 48, P'(400) = 36,$   
 $P'(600) = 24$

e.  $x = 200, x = 1800$

21. a.  $P(x) = -0.2x^2 + 75x - 2070$

b.  $P(60) = \$1710, P(80) = \$2650,$   
 $P(100) = \$3430$

c.  $P'(x) = -0.4x + 75$

d.  $P'(60) = 51, P'(80) = 43,$   
 $P'(100) = 35$

e.  $x = 30, x = 345$

23. a.  $R(x) = 46x + 0.25x^2$

b.  $P(x) = 0.1x^2 + 40x - 190$

c.  $P(25) = \$872.50,$   
 $P(30) = \$1100, P(40) = \$1570$

d.  $P'(x) = 0.2x + 40$

e.  $P'(25) = 45, P'(30) = 46,$   
 $P'(40) = 48$

25. a.  $R(x) = 5.5x - 0.0004x^2$

b.  $P(x) = -0.0006x^2 + 4.5x$   
 $- 4650$

c.  $P(3000) = 3450,$   
 $P(3500) = 3750,$   
 $P(4000) = 3750$

d.  $P'(x) = -0.0012x + 4.5$

e.  $P'(3000) = 0.9,$   
 $P'(3500) = 0.3,$   
 $P'(4000) = -0.3$

27. a.  $f(0) = 12,519.30$ . This year, the value of the car is \$12,519.30.

b.  $f'(x) = -1391.10$ . As the age of the car increases, the value of the car decreases at the rate of \$1391.10/year.

29. a.  $F'(t) = \frac{-8.4t^3}{10^6} + \frac{4.8t^2}{10^4}$   
 $-0.00914t + 0.0994$

b.  $F(30) = 7.518$  billion

c.  $F'(30) = 0.0304$  billion. In the year 2030, the world population is increasing at the rate of 0.0304 billion/year.

$$31. \text{ a. } H'(t) = \frac{-10.4t^3}{10^6} + \frac{5.61t^2}{10^4} - 0.00792t + 0.116$$

$$\text{ b. } H(30) = 8.909 \text{ billion}$$

c.  $H'(30) = 0.1025$  billion. In the year 2030, the world population is increasing at the rate of 0.1025 billion/year.

33. Argue against; Answers will vary.

Note:  $\frac{R(x)}{x}$  is also  $D(x)$ .

## Chapter 11: More about the Derivative

### 11.1 EXERCISES

$$1. f'(x) = -8x^3 + 9x^2 + 2x$$

$$3. f'(x) = \frac{15x^2 + 1}{2\sqrt{x}}$$

$$5. f'(x) = 8x$$

$$7. g'(x) = -\frac{1}{x^2}$$

$$9. g'(x) = 6 - 10x^4$$

$$11. 5x^2(x^2 + 3) \quad 13. \frac{3}{2} \left( \frac{4t+1}{\sqrt{t}} \right)$$

$$15. \frac{\sqrt{x}(5x+3)}{2}$$

$$17. -18u^2 + 20u - 9$$

$$19. \frac{1}{5t^2}(50t^3 + 5t^2 - 1)$$

$$21. 18(x+6)^{-2}$$

$$23. -15(x-7)^{-2}$$

$$25. \frac{x^4 + 3x^2 + 10x}{(x^2 + 1)^2}$$

$$27. \frac{9-x}{2\sqrt{x}(x+9)^2}$$

$$29. \frac{3u^{\frac{3}{2}} + 4u}{2(\sqrt{u} + 1)^2}$$

$$31. \frac{3t^2 - 16t^{\frac{3}{2}} - 3}{2\sqrt{t}(t^2 + 3)^2}$$

$$33. \frac{6x - 15 + 10x^{\frac{4}{3}} - 20x^{\frac{1}{3}}}{3(1 + 2\sqrt[3]{x})^2}$$

$$35. h'(2) = 1 \quad 37. h'(2) = \frac{10}{3}$$

$$39. h'(2) = \frac{129}{256} \quad 41. h'(2) = \frac{1}{3}$$

$$43. h'(2) = -\frac{7}{121}$$

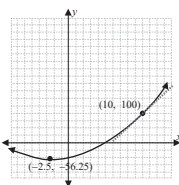
$$45. y = 616.5x - 1766$$

$$47. y = -\frac{19}{25}x + \frac{2}{5}$$

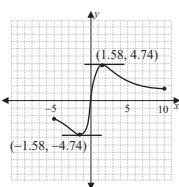
$$49. y = -\frac{17}{20}x + \frac{37}{20}$$

$$51. (x, y) = (-2, 36), \text{ and } \left( \frac{8}{3}, -\frac{400}{27} \right)$$

$$53. (x, y) = (10, 100)$$



55.



$$(-1.58, -4.74), (1.58, 4.74)$$

$$57. \$1.15/\text{item} \quad 59. \$13.20/\text{item}$$

$$61. 6100 \text{ people/year}$$

### 11.2 EXERCISES

$$1. 8(2x-5)^3 \quad 3. -12(1-4x)^2$$

$$5. -4x(x^2 + 4)^{-3}$$

$$7. -3(4t+3)(2t^2 + 3t)^{-4}$$

$$9. 16x^3 + 60x^2 - 6x - 70$$

$$11. \frac{3x^2}{2\sqrt{x^3+1}} \quad 13. \frac{8x}{3(4x^2+1)^{\frac{2}{3}}}$$

$$15. -\frac{3x^2}{2(1-2x^3)^{\frac{3}{4}}}$$

$$17. 5(13t^3 + 3)(t^3 + 3)^3$$

$$19. 6x^2(x^2 - 8)^2(3x^2 - 8)$$

$$21. -\frac{x}{(x^2 + 6)^{\frac{3}{2}}} \quad 23. \frac{8}{(t^2 + 8)^{\frac{3}{2}}}$$

$$25. -\frac{(10x+18)}{3x^3(2x+3)^{\frac{2}{3}}}$$

$$27. \frac{18x-13}{2(3x-4)^{\frac{1}{2}}} \quad 29. \frac{26(3x-2)}{(5x+1)^3}$$

$$31. \frac{5t-17}{3(t-1)^{\frac{5}{3}}}$$

$$33. -9(2t+5)^2(t+1)^{-4}$$

$$35. \frac{5}{(4-2x)^{\frac{3}{2}}(x+3)^{\frac{1}{2}}}$$

$$37. -\frac{7}{2(3x-1)^{\frac{3}{2}}(x+2)^{\frac{1}{2}}}$$

$$39. (7-2x)^{-\frac{3}{2}}(-3x^2 + 13x + 7)$$

$$41. -48$$

$$43. -\frac{3}{4}$$

$$45. \frac{135}{2}$$

$$47. -\frac{7}{8}$$

$$49. 295$$

$$51. -48$$

$$53. -7$$

$$55. 480$$

$$57. y = 36x - 28$$

$$59. y = \frac{13}{8}x + \frac{3}{2}$$

$$61. \text{ a. } R(x) = 20x\sqrt{280-4x}$$

$$\text{ b. } \$5880$$

$$\text{ c. } R'(x) = 40\sqrt{70-x} - \frac{20x}{\sqrt{70-x}}$$

$$\text{ d. } \$220 \text{ per oven}$$

$$63. \text{ a. } 18,560 \text{ people}$$

$$\text{ b. } 640 \text{ people/year}$$

$$65. 218 \text{ units per day}$$

67. a. \$140.83/hour  
 b. \$109.48/hour
69. a. 2.5 ppm/year  
 b. 30 ppm/year
71. a. 1789 people  
 b.  $N'(5) = 0.05$   
 c. The rate of attendance is increasing at a rate of 50 people per week.
73. a.  $P(0) = 2.0$  million students; represents the number of students registered in calculus in 1995.  
 b.  $P'(t) = -\frac{1}{12}\left(1 - \frac{t}{30}\right)^{1.5}$   
 c.  $P'(10) = -0.045$ . The rate of registration was decreasing 45,000 students/year in 2005.

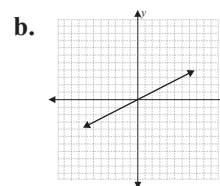
### 11.3 EXERCISES

1.  $\frac{dy}{dx} = -\frac{2x}{y}$     3.  $\frac{dy}{dx} = -\frac{2x^2}{y^2}$
5.  $\frac{dy}{dx} = -\frac{\sqrt{y}}{\sqrt{x}}$     7.  $\frac{dy}{dx} = -\frac{2y}{x}$
9.  $\frac{dy}{dx} = -\frac{(2x+y)}{(x+2y)}$
11.  $\frac{dy}{dx} = \frac{2-8x-3y}{3x+2y}$
13.  $\frac{dy}{dx} = \frac{x^2y-2x^2y^2-y^2}{x^3}$
15.  $\frac{dy}{dx} = \frac{4x^2y^{\frac{1}{2}}+y}{8x^2y^{\frac{3}{2}}-x}$
17.  $\frac{dy}{dx} = \frac{4x^3-2xy^2-y^3}{2x^2y+3xy^2}$
19.  $\frac{dy}{dx} = \frac{x}{2-y}$
21.  $\frac{dy}{dx} = \frac{x}{3y^2}; m = \frac{2}{3}$
23.  $\frac{dy}{dx} = \frac{4+2xy}{2y-x^2}; m = \frac{12}{7}$
25.  $\frac{dy}{dx} = \frac{3x^2+2y}{2(y-x)}; m = -\frac{7}{4}$

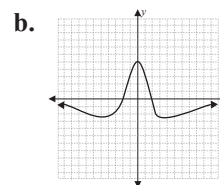
27.  $\frac{dy}{dx} = \frac{x^2y-y^3-2x^2y^3}{2x^3}; m = 1$
29.  $\frac{dy}{dx} = \frac{20x^{\frac{3}{2}}y^{\frac{1}{2}}-y}{4x^2y^{\frac{1}{2}}+x}; m = \frac{76}{9}$
31.  $\frac{dy}{dt} = \frac{x}{4y} \frac{dx}{dt}$
33.  $\frac{dy}{dt} = \frac{2-3x^2}{10y} \frac{dx}{dt}$
35.  $\frac{dy}{dt} = -\frac{y}{x} \frac{dx}{dt}$
37.  $\frac{dy}{dt} = -\frac{(2x+y)}{x+2y} \frac{dx}{dt}$
39.  $\frac{dy}{dt} = \frac{(x+y)}{y-x} \frac{dx}{dt}$
41.  $\frac{5}{4}$  speakers per receiver; the number of speakers sold in a week increases by 1.25 for each additional receiver sold
43.  $-\frac{27}{64}$  units of capital/week
45. \$312/week    47.  $-\frac{4}{8} \text{ f / sec}$
49. 35.4 ft/sec
51. a. 4.5 seconds  
 b.  $\frac{20x}{y}$     c.  $10\sqrt{2}$  ft/sec
53. a.  $p = \$2$     b. \$0.38/day
55. a. 800 bears  
 b.  $\frac{dx}{dp} = -\frac{x}{p-1}; 228.571$
57. a. (504, 672)    b.  $\frac{dy}{dx} = -\frac{x}{y}$   
 c.  $\left. \frac{dy}{dx} \right|_{t=t_0} = -0.75$ ;  
 at this point in time, for every 75 ft the car travels vertically, it also travels 100 ft to the negative horizontal.  
 d.  $\left. \frac{dy}{dt} \right|_{t=t_0} = 37.5 \text{ mph}$
59. a.  $S = 12$   
 b.  $\frac{dp}{dn} = -\frac{p-p^2}{n(1-2p)}; -0.00049$

### 11.4 EXERCISES

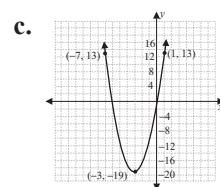
1. a.  $(2, +\infty)$     b.  $(-\infty, 2)$
3. a.  $(-\infty, 2)$     b.  $(2, +\infty)$
5. a.  $(-1, 2)$   
 b.  $(-\infty, -1), (2, +\infty)$
7. a.  $(-2, -1), (2, +\infty)$   
 b.  $(-\infty, -2), (-1, 2)$
9. a.  $(-\infty, -2), (0, 6)$   
 b.  $(-2, 0), (6, +\infty)$
11. a. Inc.:  $(0, +\infty)$ ; Dec.:  $(-\infty, 0)$



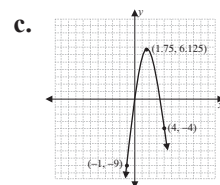
13. a. Inc.:  $(-2, 2)$ ;  
 Dec.:  $(-\infty, -2), (2, +\infty)$

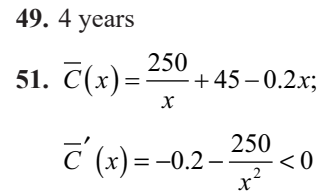
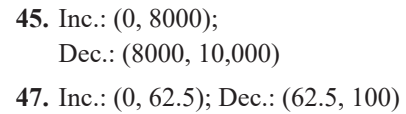
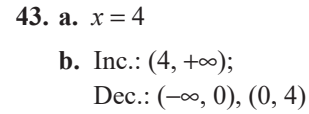
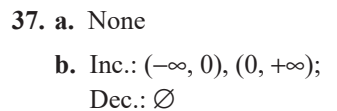
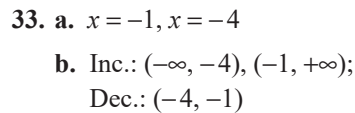
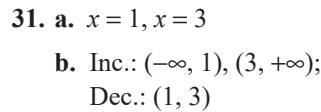
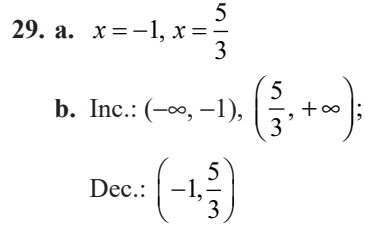
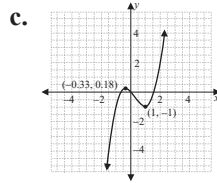
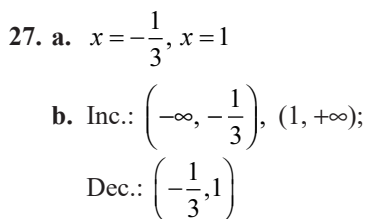
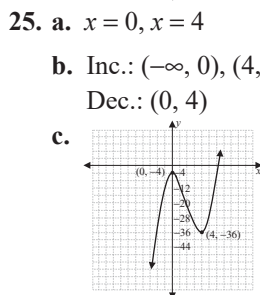
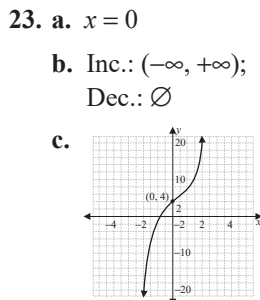
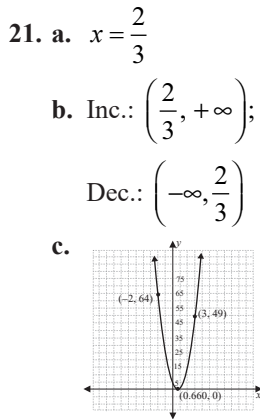
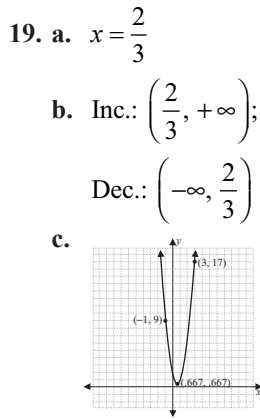


15. a.  $x = -3$   
 b. Inc.:  $(-3, +\infty)$ ; Dec.:  $(-\infty, -3)$

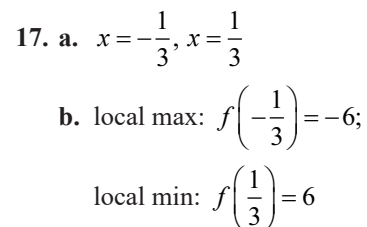
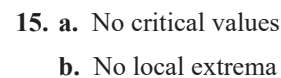
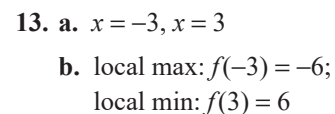
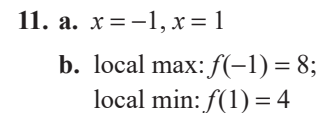
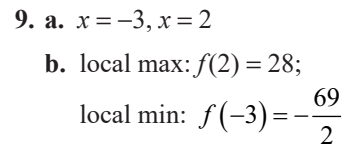
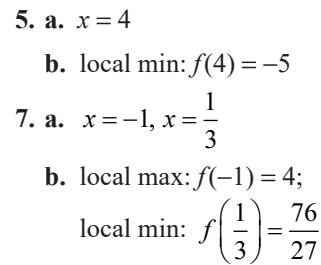
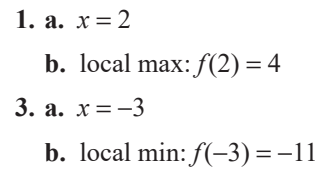


17. a.  $x = \frac{7}{4}$   
 b. Inc.:  $(-\infty, \frac{7}{4})$ ;  
 Dec.:  $(\frac{7}{4}, +\infty)$





### 11.5 EXERCISES



19. a.  $x = \frac{1}{2}$   
 b. local min:  $f\left(\frac{1}{2}\right) = 12$
21.  $W'(t) = \frac{2100t}{(t^2 + 15)^2} > 0$ ,  
 so  $W(t)$  is increasing;  
 $\lim_{t \rightarrow +\infty} W(t) = 130$
23.  $(0, \infty)$  increasing
25.  $F'(t) = -\frac{8000t}{(t^2 + 40)^2} < 0$ ,  
 so  $F(t)$  is decreasing;  
 $\lim_{t \rightarrow \infty} F(t) = 80$
27.  $F'(t) = -\frac{3300t}{(t^2 + 10)^2} < 0$ ,  
 so  $F(t)$  is decreasing;  
 $\lim_{t \rightarrow \infty} F(t) = 15$
29. at  $t = 50$ ,  $-99.5\%$  of light speed
31.  $(5.2, 85)$  increasing; maximum efficiency at  $v = 5.2$

### 11.6 EXERCISES

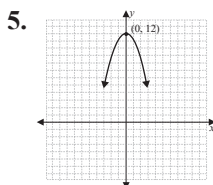
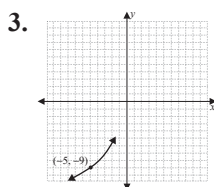
1. Abs. min.:  $(5, 3)$ ;  
 Abs. max.:  $(3, 6)$
3. Abs. min.:  $(3, 2)$ ;  
 Abs. max.:  $(-5, 8)$
5. Abs. min.:  $(4, 4)$ ;  
 Abs. max.:  $(2, 10)$
7. Abs. min.:  $(5, -1)$ ;  
 Abs. max.:  $(3, 6)$
9.  $f(4) = -16$  min;  $f(0) = 0$  max
11.  $f(3) = 27$  min;  $f(5) = 31$  max
13.  $f(4) = 2$  min;  $f(0) = 14$  max
15.  $f(3) = -19$  min;  $f(-1) = 9$  max
17.  $f(2) = -16$  min;  
 $f(-2) = f(4) = 16$  max
19.  $f\left(\frac{1}{3}\right) = -\frac{1}{27}$  min;  
 $f(2) = 12$  max
21.  $f(-3) = -27$  min;  $f(1) = 5$  max
23.  $f(2) = -30$  min;  $f(4) = 22$  max
25.  $f(0) = -4$  min;  $f(8) = 0$  max
27.  $f(1) = -1$  min;  $f\left(\frac{1}{8}\right) = 1$  max
29.  $f(0) = 2$  min;  $f(2) = 2\sqrt{2}$  max

31.  $f(0) = -1$  min;  
 $f(-2) = f(2) = \sqrt[3]{3}$  max
33.  $f(2) = 4$  min;  $f\left(\frac{1}{2}\right) = 8.5$  max
35.  $f(1.5) = 12$  min;  $f(3) = 15$  max
37.  $f(2) = 12$  min;  
 $f\left(\frac{1}{2}\right) = 32.25$  max
39. 24 units
41. 40 telescopes
43. 120 refrigerators
45. 1:00 p.m.
47. 1600 bacteria at time  $t = 6$
49.  $F\left(\frac{65}{3}\right) = 7041.\bar{6}$  ft
51.  $t = 34.32$ ; 41.77%; yes
53. 500 newtons,  $v = 2500$
55.  $F(0.8) = 666.\bar{6}$ ; yes
57. max at  $(0, 75)$ ; min at  $(5, 10)$
59. at  $t = 25.11$ , 0.048 moles per sec.;  
 at  $t = 62.01$ , 0.025 moles per sec.
61. at  $t = 20$  nanosec.;  $E(20) = 15$
63. 31<sup>st</sup> day; 3.298 million

## Chapter 12: Applications of the Derivative

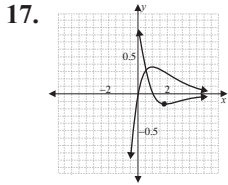
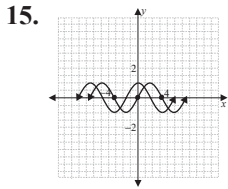
### 12.1 EXERCISES

1. At A:  $f'$  is positive;  
 $f''$  is positive  
 At B:  $f'$  is positive;  
 $f''$  is zero  
 At C:  $f'$  is zero;  
 $f''$  is negative  
 At D:  $f'$  is negative;  
 $f''$  is zero  
 At E:  $f'$  is negative;  
 $f''$  is positive



7.  $f''(x) = 6x - 2$ ;  
 $f''(0) = -2$ ;  $f''(1) = 4$ ;  
 $f''(4) = 22$
9.  $f''(x) = 2 - \frac{1}{3x^2}$ ;  
 $f''(0)$  = does not exist;  
 $f''(1) = \frac{3}{2}$ ;  $f''(4) = \frac{31}{16}$

11.  $f''(x) = -\frac{1}{(2x+1)^{\frac{3}{2}}}$ ;  
 $f''(0) = -1$ ;  $f''(1) = -\frac{1}{3\sqrt{3}}$ ;  
 $f''(4) = -\frac{1}{27}$
13.  $f''(x) = -\frac{12}{(x+4)^3}$ ;  
 $f''(0) = -\frac{3}{16}$ ;  $f''(1) = -\frac{12}{125}$ ;  
 $f''(4) = -\frac{3}{128}$



19. a.  $(-3, -1), (-1, 1)$   
 b.  $(-\infty, -3), (1, \infty)$   
 c.  $(-3, 2), (1, 2)$
21. a.  $(-\infty, -3), (1, 5), (5, \infty)$   
 b.  $(-3, 1)$   
 c.  $(-3, 3), (1, 4)$
23. a.  $(-\infty, +\infty)$  b. None  
 c. None
25. a.  $(-2, +\infty)$  b.  $(-\infty, -2)$   
 c.  $(-2, 6)$
27. a.  $(0, +\infty)$  b.  $(-\infty, 0)$   
 c.  $(0, 2)$
29. a.  $(-3, +\infty)$  b.  $(-\infty, -3)$   
 c.  $(-3, 7)$
31. a.  $(-\infty, \frac{3}{5})$  b.  $(\frac{3}{5}, \infty)$   
 c.  $(\frac{3}{5}, 0)$
33. a.  $(-\sqrt{5}, 0), (\sqrt{5}, \infty)$   
 b.  $(-\infty, -\sqrt{5}), (0, \sqrt{5})$   
 c.  $(0, 0)$
35.  $G(x) = x^4$
37.  $J(x) = (x - 4)^3$

### 12.2 EXERCISES

1.  $f'(x) = 14x - 28; f''(x) = 14;$   
 Max:  $\emptyset$ ; Min:  $(2, -20)$ ; I:  $\emptyset$ ;  
 Con. up:  $\mathbb{R}$ ; Con. down:  $\emptyset$
3.  $f'(x) = 6x^2 + 5; f''(x) = 12x;$   
 Max:  $\emptyset$ ; Min:  $\emptyset$ ; I:  $(0, -1)$ ;  
 Con. up:  $(0, +\infty)$ ;  
 Con. down:  $(-\infty, 0)$

5.  $f'(x) = 3x^2 + \frac{1}{\sqrt{x}};$   
 $f''(x) = 6x - \frac{1}{2x^{\frac{3}{2}}};$

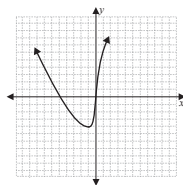
Max:  $\emptyset$ ; Min:  $(0, 5)$ ;  
 I:  $(0.3701, 6.2674)$ ;  
 Con. up:  $(0.3701, +\infty)$ ;  
 Con. down:  $(0, 0.3701)$

7.  $f'(x) = 4x(x^2 + 7);$   
 $f''(x) = 12x^2 + 28;$   
 Max:  $\emptyset$ ; Min:  $(0, 49)$ ; I:  $\emptyset$ ;  
 Con. up:  $\mathbb{R}$ ; Con. down:  $\emptyset$

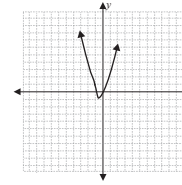
9.  $f'(x) = \frac{x}{\sqrt{x^2 + 3}};$   
 $f''(x) = 3(x^2 + 3)^{-\frac{3}{2}};$   
 Max:  $\emptyset$ ; Min:  $(0, \sqrt{3})$ ; I:  $\emptyset$ ;  
 Con. up:  $\mathbb{R}$ ; Con. down:  $\emptyset$

11.  $f'(x) = \frac{3(1-x^2)}{(x^2+1)^2};$   
 $f''(x) = \frac{6x(x^2-3)}{(x^2+1)^3};$   
 Max:  $(1, 1.5)$ ; Min:  $(-1, -1.5)$ ;  
 I:  $(0, 0), (-\sqrt{3}, \frac{-3\sqrt{3}}{4}),$   
 $(\sqrt{3}, \frac{3\sqrt{3}}{4});$   
 Con. up:  $(-\sqrt{3}, 0), (\sqrt{3}, +\infty)$ ;  
 Con. down:  $(0, \sqrt{3}), (-\infty, -\sqrt{3})$

13. POI:  $(2.5, 10.179), (0, 0);$   
 min:  $(-\frac{5}{4}, -4.04)$

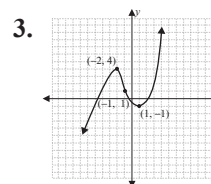
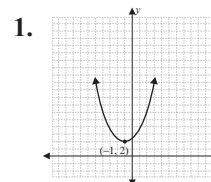


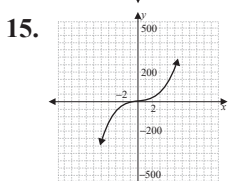
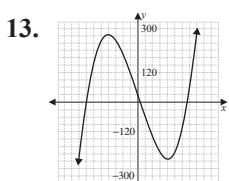
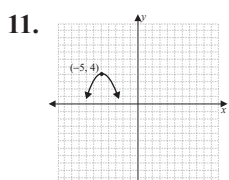
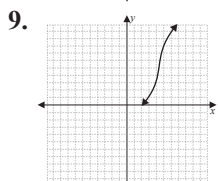
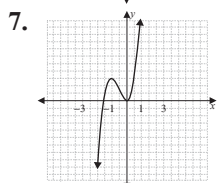
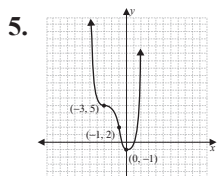
15. POI:  $(-1, 0), (-1.5, 2.38);$   
 min:  $(-\frac{3}{4}, -0.94)$



17. Local min:  $f(\frac{3}{2}) = \frac{11}{4}$
19. Local max:  $f(0) = 8;$   
 Local min:  $f(2) = 4$
21. Local max:  $f(-2) = 19;$   
 Local min:  $f(2) = -13$
23. Local max:  $f(-1) = \frac{1}{3};$   
 Local min:  $f(2) = -\frac{26}{3}$
25. Local max:  $f(0) = 7;$   
 Local min:  $f(2) = -9, f(-2) = -9$
27. Local min:  
 $f(-\frac{3}{2}) = -\frac{91}{16}$
29. Local max:  $f(-2) = -8;$   
 Local min:  $f(2) = 8$
31.  $x = \$6000$
33.  $C'(8) = \$4.80/\text{unit}$
35. a.  $N(9) = 104.6$  crimes  
 b.  $N'(4) = 8$  crimes/month
37. a. Max/min cannot exist;  
 POI at  $x = 0$   
 b. Max/min can exist; POI at  
 $x = 0$   
 c. No  
 d. Answers will vary.

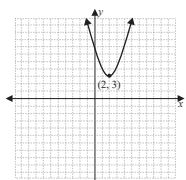
### 12.3 EXERCISES





$y = \frac{4}{3}x^3 + 2x^2 + 5x + 2$   
is implied.

17.  $(-\infty, 2)$ ;  $f'(x) < 0$ ; Decreasing  
 $(2, +\infty)$ ;  $f'(x) > 0$ ; Increasing  
 $x = 2$ ;  $f'(2) = 0$ ; Local min  
 $(-\infty, +\infty)$ ;  $f''(x) = 2 > 0$ ;  
Hence  $f''(2) = 2 > 0$  and  
concave up on  $(-\infty, \infty)$ .



19.  $(-\infty, \frac{5}{2})$ ;  $f'(x) > 0$ ;

Increasing

$(\frac{5}{2}, +\infty)$ ;  $f'(x) < 0$ ;

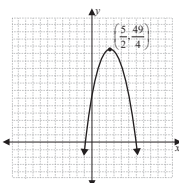
Decreasing

$x = \frac{5}{2}$ ;  $f'(\frac{5}{2}) = 0$ ;

Local max

$(-\infty, +\infty)$ ;  $f''(x) = -2 < 0$ ;

Concave down on  $(-\infty, \infty)$ .



21.  $(-\infty, -2)$ ,  $(0, \infty)$ ;  
 $f'(x) > 0$ ; Increasing  
 $(-2, 0)$ ;  $f'(x) < 0$ ;

Decreasing

$x = -2$ ;  $f'(-2) = 0$ ;

Local max

$x = 0$ ;  $f'(0) = 0$ ;

Local min

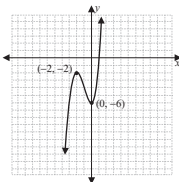
$(-\infty, -1)$ ;  $f''(x) < 0$ ;

Concave down

$(-1, +\infty)$ ;  $f''(x) > 0$ ;

Concave up

$x = -1$ ;  $f''(-1) = 0$ ; POI



23.  $(-\infty, -3)$ ,  $(1, +\infty)$ ;  
 $f'(x) > 0$ ; Increasing  
 $(-3, 1)$ ;  $f'(x) < 0$ ;

Decreasing

$x = -3$ ;  $f'(-3) = 0$ ; Local max

$x = 1$ ;  $f'(1) = 0$ ; Local min

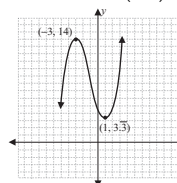
$(-\infty, -1)$ ;  $f''(x) < 0$ ;

Concave down

$(-1, +\infty)$ ;  $f''(x) > 0$ ;

Concave up

$x = -1$ ;  $f''(-1) = 0$ ; POI



25.  $(-\infty, -1)$ ,  $(0, 1)$ ;  
 $f'(x) < 0$ ; Decreasing

$(-1, 0)$ ,  $(1, +\infty)$ ;

$f'(x) > 0$ ; Increasing

$x = -1$ ;  $f'(-1) = 0$ ; Local min

$x = 0$ ;  $f'(0) = 0$ ; Local max

$x = 1$ ;  $f'(1) = 0$ ; Local min

$(-\infty, -\frac{1}{\sqrt{3}})$ ,  $(\frac{1}{\sqrt{3}}, +\infty)$ ;

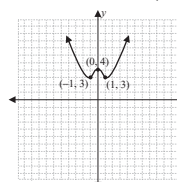
$f''(x) > 0$ ; Concave up

$(-\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$ ;  $f''(x) < 0$ ;

Concave down

$x = -\frac{1}{\sqrt{3}}$ ;  $f''(-\frac{1}{\sqrt{3}}) = 0$ ; POI

$x = \frac{1}{\sqrt{3}}$ ;  $f''(\frac{1}{\sqrt{3}}) = 0$ ; POI



27.  $(-\infty, 3)$ ;  $f'(x) < 0$   
except  $x = 0$ ; Decreasing  
 $(3, +\infty)$ ;  $f'(x) > 0$ ; Increasing  
 $x = 3$ ;  $f'(3) = 0$ ; Local min  
 $(-\infty, 0)$ ,  $(2, +\infty)$ ;  $f''(x) > 0$ ;

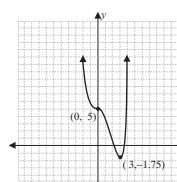
Concave up

$(0, 2)$ ;  $f''(x) < 0$ ;

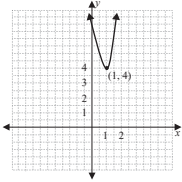
Concave down

$x = 0$ ;  $f''(0) = 0$ ; POI

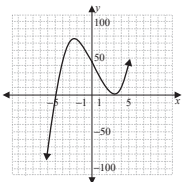
$x = 2$ ;  $f''(2) = 0$ ; POI



29.  $(-\infty, 1); f'(x) < 0$ ;  
 Decreasing  
 $(1, +\infty); f'(x) > 0$ ;  
 Increasing  
 $x = 1; f'(1) = 0$ ; Local min  
 $(-\infty, +\infty); f''(x) > 0$ ;  
 Concave up

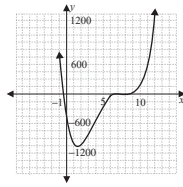


31.  $(-\infty, -\frac{7}{3}), (3, +\infty); f'(x) > 0$ ;  
 Increasing;  
 $(-\frac{7}{3}, 3); f'(x) < 0$ ; Decreasing;  
 $x = -\frac{7}{3}; f'(-\frac{7}{3}) = 0$ ;  
 Local max.;  
 $x = 3; f'(3) = 0$ ; Local min.;  
 $(-\infty, \frac{1}{3}); f''(x) < 0$ ;  
 Concave down;  
 $(\frac{1}{3}, +\infty); f''(x) > 0$ ;  
 Concave up;  
 $x = \frac{1}{3}; f''(\frac{1}{3}) = 0$ ; POI

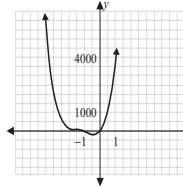


33.  $(-\infty, 1.62); f'(x) < 0$ ; Decreasing;  
 $(1.62, +\infty); f'(x) > 0$  except  $x = 8$ ;  
 Increasing;  
 $x = 1.62; f'(1.62) = 0$ ; Local min.;  
 $(-\infty, 3.75), (8, +\infty); f''(x) > 0$ ;  
 Concave up;  
 $(3.75, 8); f''(x) < 0$ ; Concave down;  
 $x = 3.75; f''(3.75) = 0$ ; POI;

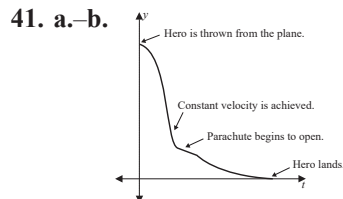
$x = 8; f'''(8) = 0$ ; POI



35.  $(-\infty, -0.4); f'(x) < 0$  except  
 $x = -1.6$ ; Decreasing;  
 $(-0.4, +\infty); f'(x) > 0$ ; Increasing;  
 $x = -0.4; f'(-0.4) = 0$ ; Local min.;  
 $(-\infty, -1.6), (-0.8, +\infty);$   
 $f''(x) > 0$ ; Concave up;  
 $(-1.6, -0.8); f''(x) < 0$ ;  
 Concave down;  
 $x = -1.6; f''(-1.6) = 0$ ; POI;  
 $x = -0.8; f''(-0.8) = 0$ ; POI



37. 3                      39. 3

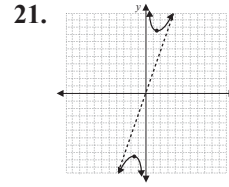
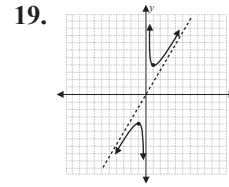
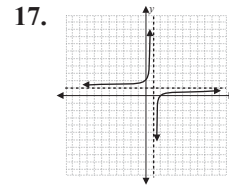
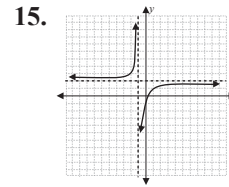
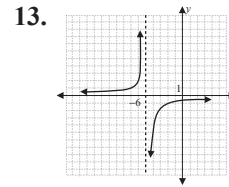


43. a. at  $x = 5$   
 b. The workers should do the most demanding work starting 1 hour and 15 min. after their arrival to 7 hours and 15 min. into their work day. The first 1 hour and 15 min. and the last 45 min. of their day should be spent on the easier tasks. Doing so will achieve a PR of 25.02.

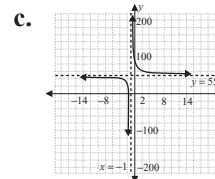
12.4 EXERCISES

1. a.  $x = 4$     b.  $y = 0$     c. None  
 3. a.  $x = -8$     b.  $y = 2$     c. None  
 5. a. None    b.  $y = 0$     c. None  
 7. a.  $x = 1, x = -\frac{1}{3}$   
       b.  $y = \frac{5}{3}$     c. None

9. a.  $x = 0$     b. None    c.  $y = x$   
 11. a.  $x = -1$     b. None  
       c.  $y = x - 1$

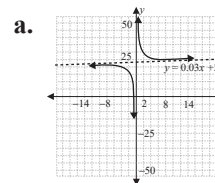


23. a.  $F(0) = \$7000$   
 b.  $x = -1$  is a vertical asymptote;  
 $y = 55$  is a horizontal asymptote.



- d. \$5500

25.  $A(x) = \frac{0.03x^2 + 24x + 10}{x}$

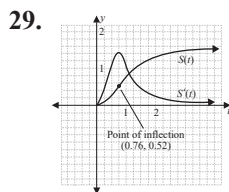


- b.  $x = 0$  is a vertical asymptote;  $y = 0.03x + 24$  is an oblique asymptote. Average cost is modeled by the oblique asymptote at large values.
- 27. a. 32 dinars  
b.  $x = -3$  is a vertical asymptote (not significant),  $y = 20$  is a horizontal asymptote, (Average cost always exceeds 20 dinars.)  
c. In the year 2007
- 29. a.  $y = 8$  is a horizontal asymptote.  
b. 4 million

### 12.5 EXERCISES

- 1. 25 vacuum cleaners per order; 5 orders per year
- 3. 30 copies per order; 3 orders per year
- 5. 200 sweatshirts per order; 20 orders per year
- 7. 120 snowmobiles per order; 8 orders per year
- 9. \$24                      11. 75 cents
- 13. 5 salespeople 15. \$6

- 17. 13 units at \$36
- 19. 1900 microwave ovens at \$326
- 21. a. The company is making \$12,000.  
b. The profit will rise \$2 per cell phone.  
c. The rate of profit increase is dropping.
- 23. a.  $R(x) = 12x$   
b.  $P(x) = -0.3x^2 + 10x - 5$   
c.  $P(16.67) = 78.33$
- 25. a.  $C(x) = 0.2x^2 + 3x$   
b.  $A'(x) = 0.2$   
c.  $C'(x) = 0.4x + 3$
- 27. a. \$26,666.67  
b. Value is increasing.  
c. Yes. We can use test values with  $V'$  to determine if  $V'$  is in fact increasing or not (this rate of change is  $V''$ ).



### 12.6 EXERCISES

- 1. 4 in. by 4 in.
- 3.  $\frac{5}{3}$  in. by  $\frac{14}{3}$  in. by  $\frac{35}{3}$  in.
- 5. a. 12 in. by 12 in. by 6 in.  
b. 432 in.<sup>2</sup>
- 7. 2 ft by 2 ft by 2.5 ft
- 9. 1.82 ft
- 11. 18.5 ft by 37 ft
- 13. 70 ft by 70 ft; 4900 ft<sup>2</sup>
- 15. 36 ft by 69 ft
- 17.  $\frac{65}{3}$  in. by  $\frac{65}{3}$  in. by  $\frac{130}{3}$  in.;  $\frac{260}{9}$  in. by  $\frac{260}{9}$  in. by  $\frac{65}{3}$  in. yields a package of lesser volume
- 19. 3 miles from point A
- 21. 0.8 miles from point A
- 23. a. 67 ft/sec    b. 129 ft
- 25. a. 324 ft    b. 8 sec  
c. 144 ft/sec

## Chapter 13: Additional Applications of the Derivative

### 13.1 EXERCISES

- 1.  $f'(x) = 2x - \frac{1}{x}$
- 3.  $f'(x) = 1 + \ln x$
- 5.  $\frac{dy}{dx} = \frac{1 - \ln x}{x^2}$
- 7.  $\frac{dy}{dx} = \frac{3}{x}(\ln x)^2$
- 9.  $f'(x) = \frac{5}{5x + 3}$
- 11.  $f'(x) = \frac{2x}{x^2 + 2}$
- 13.  $f'(x) = \frac{2x}{2x^2 - 1}$
- 15.  $\frac{dy}{dx} = \frac{8}{4x + 3}$
- 17.  $\frac{dy}{dx} = \frac{2x^{\frac{3}{2}}}{x^2 + 2} + \frac{\ln(x^2 + 2)}{2\sqrt{x}}$
- 19.  $\frac{dy}{dx} = \frac{2x + 2}{x(x^2 + 2x - 1)} - \frac{\ln(x^2 + 2x - 1)}{x^2}$
- 21.  $f'(x) = \frac{9x^2 + 2x + 9}{(3x + 1)(x^2 + 3)}$
- 23.  $f'(x) = \frac{8x^2 - 2x - 8}{(2x - 1)(x^2 - 2)}$
- 25.  $\frac{dy}{dx} = -\frac{3}{(x + 1)(x - 2)}$
- 27.  $f'(x) = \frac{2x^2 + 18x + 10}{(x^2 - 5)(2x + 9)}$
- 29.  $f''(x) = \frac{2 - \ln x}{x(\ln x)^3}$   
 $x = e^2 \approx 7.39$ ;  $(e^2, 3.7)$
- 31.  $f''(x) = 9 + 6 \ln x$ ;  
 $x = e^{-\frac{3}{2}}$ ;  $(e^{-\frac{3}{2}}, -0.224)$
- 33.  $f''(x) = \frac{3 \ln x}{x^2} [2 - \ln x]$ ;  
 $x = 1$ ,  $x = e^2 \approx 7.39$ ;  
 $(1, 0)$ ,  $(e^2, 8)$
- 35.  $\frac{dy}{dx} = \frac{(2x - 5)^2 (8x^2 - 19x + 5)}{\sqrt{x^2 - 2x}}$
- 37.  $\frac{dy}{dx} = \frac{2x(11x^2 - 14)(x^2 + 2)^3}{3(x^2 - 1)^{\frac{4}{3}}}$

39.  $\frac{dy}{dx} = \frac{(16x^2 - 46x - 54)(2x + x^2)^2}{(4x - 9)^3}$

41.  $\frac{dy}{dx} = \frac{\left[ \frac{(21x^2 - 114x - 248)}{(x+2)(3x+4)} \right]}{2(x-6)^{\frac{3}{2}}}$

43. Abs. max.: (2, 1.31);

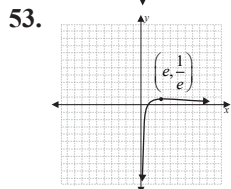
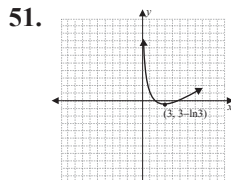
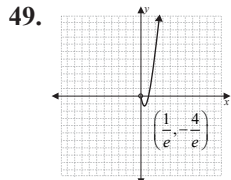
Abs. min.: (1, 1)

45. Abs. max.: (1.2, 6.58);

Abs. min.: (e, e)

47. Abs. max.: (e, 4.39);

Abs. min.: ( $\sqrt{1.5}$ , 0.89)



55.  $96 + \frac{8x}{4x^2 + 15}$  dollars per table

57. \$294.30

59. a. 54 flies, 61 flies, 0 flies

b. 63 flies

### 13.2 EXERCISES

1.  $f'(x) = f''(x) = 3e^x$

3.  $f'(x) = 2x + 5e^x$

$f''(x) = 2 + 5e^x$

5.  $f'(x) = e^x(x+1)$

$f''(x) = e^x(x+2)$

7.  $f'(x) = e^x \left( \frac{1}{x} + \ln x \right)$

$f'(1) = e$

9.  $f'(x) = -\frac{e^x}{(e^x - 1)^2}$

$f'(2) = -0.181$

11.  $f'(x) = 8e^{4x}$

$f'(-1) = 0.147$

13.  $f'(x) = 6e^{2x+1}$

$f'(0) = 6e \approx 16.310$

15.  $f'(x) = -2xe^{1-x^2}$ ;

inc. on  $(-\infty, 0)$ ; dec. on  $(0, \infty)$

17.  $f'(x) = 4e^{2x}(e^{2x} - 4)$ ;

dec. on  $(-\infty, 0.693)$ ;

inc. on  $(0.693, \infty)$

19.  $f'(x) = \frac{-0.1e^{-0.2x}}{(e^{-0.2x} + 11)^{\frac{1}{2}}}$ ;

always decreasing;

horiz. asympt.:  $y = \sqrt{11}$

21.  $f'(x) = \frac{e^x}{e^x + 1}$ ; There

is an oblique asympt. since

$f'(x) \rightarrow 1$  as  $x \rightarrow \infty$ .

23. Abs. min.:  $(-0.5, -0.18)$ ;

Abs. max.: (1, 7.39)

25. Abs. min.: (0, 0);

Abs. max.:  $(-1, e)$

27. Abs. min.:  $(-2, 0.25)$ ;

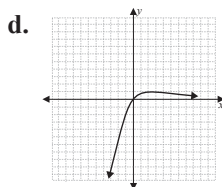
Abs. max.: (0, 13.59)

29. Abs. min.: (1, 4.09);

Abs. max.: (3.5, 4.97)

31. a.  $x = 2.5$  b.  $x = 5$

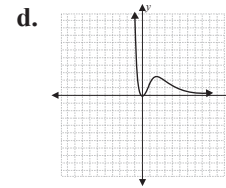
c. up:  $(5, \infty)$ ; down:  $(-\infty, 5)$



33. a.  $x = 0, 2$  b.  $x = 2 \pm \sqrt{2}$

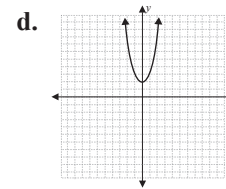
c. up:  $(-\infty, 2 - \sqrt{2})$ ,  $(2 + \sqrt{2}, \infty)$

down:  $(2 - \sqrt{2}, 2 + \sqrt{2})$



35. a.  $x = 0$  b. None

c. up:  $(-\infty, \infty)$



37. a. 20 units b. \$51.50 each

39. 10,432 people per day

41. 209 bacteria per hour

43. a. \$772.73, \$5674.72

b. \$1131.72/yr., \$859.59/yr.

c. (3.8, 4250); The rifle's value begins to increase at a much slower rate and level off.

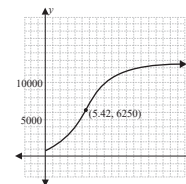
d. 2004

45. a. June 1<sup>st</sup> b. Aug 1<sup>st</sup>

47. a. 2876 videos b. 1107 videos per week

c. 39.5 weeks

d. during the 6<sup>th</sup> week



49. a.  $k = \ln 10 \approx 2.3$

b.  $k = \ln \pi \approx 1.145$

51.  $f'(x) = \frac{-3e^{-x}(x+3) - 2}{(x+2)(2+3e^{-x})}$ ;

No extrema or inflection points

### 13.3 EXERCISES

1. a.  $p(t) = 8400e^{0.035t}$

b. 11,920 people

c. 12 years, or in the year 2012

3. \$21.33      5. 9.5 hours  
 7. \$300.44      9. 26.7 years  
 11. 8700 years      13. 11.8 lb/in.<sup>2</sup>  
 15. \$18,846  
 17. 0.777; 23.1 hours  
 19. a. 800 fish      b. 4303 fish  
     c. 5.9 years  
 21. 13.5 minutes      23. \$11,880.94

### 13.4 EXERCISES

1. a.  $E(x) = \frac{28-x}{x}$   
     b.  $x = 14$   
 3. a.  $E(x) = \frac{200-x}{x}$   
     b.  $x = 100$   
 5. a.  $E(x) = \frac{5}{x}$   
     b.  $x = 5$   
 7. a.  $E(x) = \frac{40}{x}$   
     b.  $x = 40$   
 9. a.  $E(x) = \frac{2(150-x)}{x}$   
     b.  $x = 100$   
 11. a.  $E(x) = \frac{2(54-x)}{x}$   
     b.  $x = 36$   
 13. a.  $E(x) = \frac{2(18-\sqrt{x})}{\sqrt{x}}$   
     b.  $x = 144$   
 15. a.  $E(x) = \frac{363-x^2}{2x^2}$   
     b.  $x = 11$   
 17. 24 sharpeners  
 19.  $x < 121$   
 21. a. 19 video games  
     b.  $E = -\frac{pe^{-\frac{p}{10}}}{10(1-e^{-\frac{p}{10}})}$   
         At  $p = 10$ ,  $E = -0.58 < 1$  and  
         revenue is decreasing and  
         demand is inelastic.  
     c. \$189.64

23. a.  $E = 0.073 < 1$ , the demand is  
     inelastic.  
     b.  $R(x) = x\left(e^{\frac{1800}{x}-10} - 1\right)$   
     c.  $R$  is increasing as a function of  
      $p$  at  $p = 20$  ( $x \approx 137.99$ ); yes.  
 25. a.  $p = \$264.75$   
     b.  $D'(x) = -3xe^{-\frac{x^2}{200}}$   
     c.  $E = 4$       d.  $x = 10$

### 13.5 EXERCISES

1. 12      3. -2  
 5.  $4\sqrt{3}$       7.  $1/2$   
 9.  $\infty/\infty$ ;  $0.5\sqrt{x}$  dominates  
 11. 0      13.  $-\infty$   
 15. L'Hôpital's Rule does not apply;  
     the limit is 0.  
 17. 3      19. 2  
 21.  $\infty$       23.  $\infty$   
 25.  $\frac{\ln 5}{\ln 4}$       27.  $\ln 3$   
 29.  $\infty/\infty$ ; the limit is  $\sqrt{2}$ .  
 31.  $\infty^0$ ; the limit is 1.  
 33.  $\infty - \infty$ ; the limit is  $-\infty$ .  
 35.  $\infty - \infty$ ; the limit is  $-3/2$ .  
 37.  $1^\infty$ ; the limit is  $2/e$ .  
 39. Not indeterminate form; the  
     limit is  $\infty$ .  
 41.  $\infty/\infty$ ; the limit is 0.  
 43.  $\infty/\infty$ ; the limit is  $1/100$ .  
 45.  $1^\infty$ ; the limit is  $1/e$ .  
 47. 1  
 49. L'Hôpital's Rule does not apply;  
     the limit is 1.  
 51. 0      53.  $e$   
 55. 0  
 57. The limit is 0.  
 59. The limit is 0.  
 61. The limit is  $\infty$ .  
 63. The limit is 1.

65. The limit is 0.  
 67.  $1/0$  is not indeterminate;  
     l'Hôpital's Rule does not apply.  
 71.  $c = 1/2$   
 73. The theorem does not apply since  
      $g(a) = g(b)$ .  
 75.  $c = 1$   
 77.  $c_1 = -17/9$ ,  $c_2 = 1$   
 79.  $\frac{dE}{dx} \rightarrow 0$   
 81. The limit of the limits is 1.

### 13.6 EXERCISES

1.  $dy = 3x^2 dx$   
 3.  $du = 8t(2t^2 + 1) dt$   
 5.  $dA = 2\pi r dr$   
 7.  $dV = 4\pi r^2 dr$   
 9.  $dS = \left(8x - \frac{1350}{x^2}\right) dx$   
 11.  $dC = \left(3 + \frac{0.2}{\sqrt{x}}\right) dx$   
 13.  $dP = (75 - 0.4x) dx$   
 15. a. 0.64      b. 0.6  
     c. 0.04  
 17. a. 14.03      b. -15.36  
     c. 1.33  
 19. a. -17.7      b. -16.8  
     c. -0.9  
 21. a. 0.148      b. 0.15  
     c. -0.002  
 23.  $6 + \frac{1}{12}$       25.  $3 - \frac{1}{27}$   
 27.  $7 + \frac{1}{10}$       29.  $4 - \frac{17}{480}$   
 31. \$20.40      33. \$42  
 35. -340 people      37.  $19.44 \text{ in.}^3$   
 39. 0.013 ft      41.  $2400\pi \text{ in.}^3$

## Chapter 14: Integration with Applications

### 14.1 EXERCISES

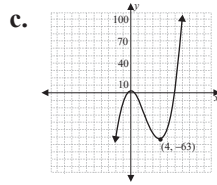
1.  $F'(x) = 4$
3.  $F'(x) = 6x + 5$
5.  $F'(x) = \frac{1}{x} + \frac{1}{x^2} - 8xe^{x^2}$
7.  $F'(x) = 8x(x^2 + 3)^3$
9.  $F'(x) = 5e^x(e^x - 4)^2$
11.  $F'(x) = \frac{2x + 5}{x^2 + 5x - 3}$
13.  $7x + C$
15.  $x^5 + C$
17.  $\frac{1}{3}x^3 - 3x + C$
19.  $\frac{1}{3}t - e^t + C$
21.  $\ln|y| + \frac{1}{4}y^4 + C$
23.  $\frac{4}{3}x^3 + 2\ln|x| - \frac{1}{x} + C$
25.  $\frac{3}{2}x^{\frac{4}{3}} + \frac{10}{3}x^{\frac{3}{2}} + C$
27.  $4e^y - \frac{1}{3}y^6 - \frac{1}{5}y + C$
29.  $3t^{\frac{2}{3}} - \frac{7}{2t^2} + C$
31.  $\frac{2}{3}e^x - 2x^{-\frac{1}{2}} - 7\ln|x| + C$
33.  $\frac{2}{5}x^5 - \frac{1}{4}x^4 + C$
35.  $3t^3 + 6t^2 + 4t + C$
37.  $\frac{2}{7}y^{\frac{7}{2}} + \frac{4}{5}y^{\frac{5}{2}} - \frac{2}{3}y^{\frac{3}{2}} + C$
39.  $3x + 5\ln|x| + \frac{4}{x} + C$
41.  $4\ln|x| + 2\sqrt{x} - 3x + C$
43.  $\frac{2}{3}x^{\frac{3}{2}} + 6\ln|x| - 2e^x + C$
45. a.  $F(x) = \frac{1}{3}x^3 - e^x + 2$   
b.  $F(x) = 2x^3 + \frac{1}{2}x^2 - 10x$

c.  $F(x) = 20\sqrt{x}$

d.  $F(x) = 6e^x - 2x - 16$

47. a.
- $x = 0$
- ; maximum,
- 
- $x = 4$
- ; minimum

b.  $x = 2$ ; POI



49.  $C(x) = 0.1x^3 - 0.4x^2 + 24x + 1500$

51.  $R(x) = 100x - 0.1x^2$

53. a.  $P(x) = 120x - \frac{3}{2}x^2 - 1050$

b. \$1350

55.  $P(t) = 16t^{\frac{3}{2}} - 20t^2 + 6300$

57.  $N(t) = \frac{960}{t} - 240t + 5000$

59. a.  $s(t) = 36t^2 - 2t^3$

b.  $s(5) = 650$

c.  $s(10) = 1600$

61. a.  $a(t) = 30 + \frac{12}{\sqrt{t}}$

b.  $s(t) = 200t + 15t^2 + 16t^{\frac{3}{2}} + 5000$

### 14.2 EXERCISES

1.  $\frac{1}{8}(x+4)^8 + C$
3.  $\frac{2}{3}(x^2 - 1)^{\frac{3}{2}} + C$
5.  $\ln|t+2| + C$
7.  $\ln|t^3 + 4| + C$
9.  $e^{y+5} + C$
11.  $e^{-0.2x} + C$
13.  $\frac{1}{5}\ln|5x+3| + C$
15.  $\frac{1}{2}\sqrt{4x-1} + C$
17.  $\frac{1}{4}e^{2x^2} + C$

19.  $-\frac{1}{6}(3x^2 - 1)^{-1} + C$

21.  $\ln|t^2 + t - 4| + C$

23.  $-\frac{5}{2}e^{-y^2} + C$

25.  $(5 + 2x^2)^{\frac{3}{2}} + C$

27.  $-4e^{\frac{1}{x}} + C$

29.  $-\frac{1}{18}(1 - 3e^{2x})^3 + C$

31.  $\frac{1}{2}(\ln x)^2 + C$

33.  $\ln|\ln x| + C$

35.  $\ln(e^x + e^{-x}) + C$

37. a.  $x + \ln|x-2| + C$

b.  $x + 2\ln|x+1| + C$

39.  $x - 2\ln|x+4| + C$

41.  $f(x) = e^{5x^2} + 10$

43.  $f(x) = \frac{(2x+2)^6}{12} + 10$

45. a.  $V(t) = 5000(25 - 1.8t)^{\frac{1}{2}}$

b. \$1250

47.  $p(x) = 14 - \frac{1}{2}\ln x$

49.  $N(t) = 6\sqrt{t^2 + 5t}$  bikes

51.  $s(t) = 36t - \frac{60}{t+1} + 4$

53. a.  $v(t) = -8(2t+1)^3 + 14$

b.  $s(t) = -(2t+1)^4 + 14t + \frac{1}{4}$

55. a. Average age of death per year

b.  $f(t) = 30\ln|1 + 0.01t| + 30$

c. 50.8 years

### 14.3 EXERCISES

1. 12
3. 21
5. 5.38

7. Left-endpoint est.  $\approx 4.146$   
(underestimate); right-endpoint  
est.  $\approx 6.146$  (overestimate);  
midpoint est.  $\approx 5.384$   
(overestimate)
9. Left-endpoint est.  $= 25/12$   
(overestimate); right-endpoint  
est.  $= 77/60$  (underestimate);  
midpoint est.  $= 496/315$   
(underestimate)
11. Left-endpoint est.  $\approx 8.119$   
(overestimate); right-endpoint  
est.  $\approx 4.924$  (underestimate);  
midpoint est.  $\approx 6.323$   
(underestimate)

### 14.4 EXERCISES

1.  $\frac{5}{3}$                       3.  $2 + e^3 \approx 22.09$
5.  $\ln 3 \approx 1.10$         7.  $\frac{1}{4}$
9. 20                      11.  $e^4 - 1 \approx 53.60$
13. 42                     15.  $\frac{1}{3} \ln 10 \approx 0.77$
17.  $\frac{1}{80}$                     19.  $\frac{121}{5}$
21.  $\frac{3}{2} \ln 33 \approx 5.24$
23.  $\frac{1}{2} [(e+1)^2 - 4] \approx 4.91$
25.  $\frac{1}{2} (e^8 - 1) \approx 1489.98$
27. 1.32
29.  $\ln(e+1) - \ln 2 \approx 0.62$
31.  $\frac{1}{2} [(1 + \ln 3)^2 - 1] \approx 1.7$
33. 13                      35.  $\frac{38}{15}$
37.  $2(1 - e^{-1}) \approx 1.26$
39.  $360(6 - \sqrt{11}) \approx 966$  ppm
41. 74.80 units

### 14.5 EXERCISES

1.  $\frac{85}{2}$                       3.  $\frac{28}{3}$

5. 4                      7.  $\frac{52}{3}$
9.  $4 \ln 4 \approx 5.55$
11.  $5(e^3 - 1) \approx 95.43$
13.  $\frac{38}{3}$                     15.  $\frac{41}{6}$
17.  $\frac{44}{3}$                     19. \$1800
21. \$1059                23. 28 bison
25. Total revenue from the sale of the  
first  $a$  units of a product.

### 14.6 EXERCISES

1.  $\frac{115}{6}$                     3.  $\frac{1}{12}$
5.  $\frac{31 - 5\sqrt{5}}{3} \approx 6.61$
7.  $6.5 + e^{-3} \approx 6.55$
9.  $\frac{15}{8} - \ln 2 + \ln \frac{1}{2} \approx 0.489$
11.  $\frac{4}{3}$                       13.  $\frac{1}{3}$
15. 36
17.  $A = 72.9$  sq. units
19.  $A \approx 0.693$  sq. units
21.  $A = 48$  sq. units
23. a. (20, \$20)  
b. \$40    c. \$100
25. a. (25, \$41)  
b. \$208.33    c. \$312.50
27. \$154.52                29. \$2.89
31. (3, 80), CS =  $\frac{135}{2}$ , PS = 45
33. a. 61 percent    b.  $\frac{7}{48}$
35. a. 27 percent    b.  $\frac{23}{75}$
37. a.  $A: 0.26; B: 0.245$     b.  $B$
39.  $A \approx 3.06$  sq. units
41.  $A \approx 2.42$  sq. units

### 14.7 EXERCISES

1.  $\frac{dy}{dx} = 6$                 3.  $\frac{dy}{dx} = e^x = 3 + y$
5.  $\frac{dy}{dx} = \frac{8}{(5-x)^3} = y^{\frac{3}{2}}$
7.  $2\frac{dy}{dx} + 3y$   
 $= 2(3e^{-1.5x}) + 3\left(\frac{1}{3} - 2e^{-1.5x}\right)$   
 $= 6e^{-1.5x} + 1 - 6e^{-1.5x} = 1$
9.  $2x^2y'' - xy' - 2y$   
 $= 2x^2(6) - x(6x + 5)$   
 $- 2(3x^2 + 5x - 2) = 4 - 15x$
11.  $x^2y'' - xy' + y$   
 $= x^2\left(\frac{1}{x}\right) - x(1 + \ln x) + x \ln x = 0$
13.  $y = \frac{3}{2}x^2 + \ln|x| + C$
15.  $y = \frac{C(x+1)^2 + 1}{2}$
17.  $y = Ce^{-0.4x}$
19.  $y = \frac{2}{5x^2 - 2x + C}$
21.  $y = \frac{20}{1 + Ce^{-12x}}$
23.  $y = 5e^{0.25x}$         25.  $y = 5x - 1$
27.  $y = \frac{2}{4x^3 - 3}$
29.  $y = 14e^{x^2} - 4$
31.  $y = \frac{120}{3 + e^{-32x}}$
33.  $D(x) = \frac{96}{x^3}$
35.  $D(x) = 18\sqrt{120 - x}$
37. a.  $V = 24,000e^{-0.06t}$   
b. \$15,769.12
39. a.  $T(t) = Ce^{-kt} + M$   
b.  $37.6^\circ$
41. a.  $N(t) = \frac{2800}{1 + 139e^{-0.84t}}$   
b. 6 days



19. Divergent    21.  $\frac{1}{3}$   
 23. Divergent    25. Divergent  
 27.  $\frac{1}{3}$         29.  $\frac{1}{2}$   
 31.  $\frac{1}{2(\ln 2)^2} \approx 1.04$

33. 1              35. 2  
 37. Area unbounded, integral divergent  
 39. d

5.  $\frac{\pi}{2}(e^4 - e^{-2}) \approx 27.2\pi$   
 7.  $\frac{16\pi}{15}$         9.  $\frac{128\pi}{3}$   
 11.  $\frac{32\pi}{3}$          13.  $\pi \ln 6 \approx 1.79\pi$   
 15.  $53.3\pi$

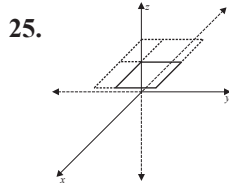
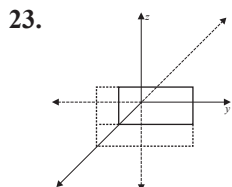
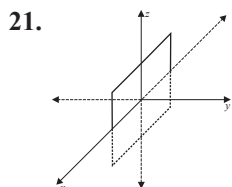
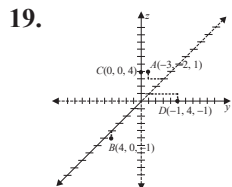
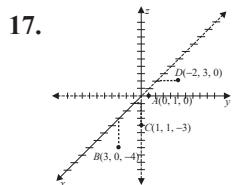
**15.6 EXERCISES**

1.  $\frac{8\pi}{3}$             3.  $32\pi$

**Chapter 16: Multivariable Calculus**

**16.1 EXERCISES**

1. a. 6    b. -12  
 3. a. 11   b. 9  
 5. a.  $\frac{11}{4}$     b. undefined  
 7. a. undefined on  $\mathbb{R}$   
    b.  $96\sqrt{2}$   
 9. a.  $6e^3 \approx 120.51$   
    b.  $-3e^{-1} \approx -1.10$   
 11. a. 1  
    b.  $2e^2 + 2 \approx 16.78$   
 13. a. 1377.13    b. 674.93  
 15. a. 1134    b. 758



27. 118  
 29. a. \$10,400    b. \$11,580  
 31. a.  $C(x, y) = 1360 + 160x + 220y$   
    b. \$6400  
 33. a.  $R(x, y) = -20x^2 - 22y^2 + 64x + 52y + 34xy$   
    b. \$336.50  
 35. a.  $V(x, y, z) = xyz$   
    b.  $S(x, y, z) = xy + 2xz + 3yz$

37. 

Number of Years (t)		
3	5	10
1195.62	1346.86	1814.02
1268.24	1485.95	2208.04
1344.89	1638.62	2685.06

**16.2 EXERCISES**

1.  $\frac{\partial f}{\partial x} = 4$ ;  $\frac{\partial f}{\partial y} = 7$   
 3.  $\frac{\partial f}{\partial x} = 4x$ ;  $\frac{\partial f}{\partial y} = 10y$   
 5.  $\frac{\partial f}{\partial x} = 2xy + 4y^3$   
     $\frac{\partial f}{\partial y} = x^2 + 12xy^2$

7.  $\frac{\partial f}{\partial x} = \frac{xy}{\sqrt{25+x^2}}$   
     $\frac{\partial f}{\partial y} = \sqrt{25+x^2}$   
 9.  $\frac{\partial f}{\partial x} = -\frac{x}{\sqrt{49-x^2-y^2}}$   
     $\frac{\partial f}{\partial y} = -\frac{y}{\sqrt{49-x^2-y^2}}$   
 11.  $\frac{\partial f}{\partial x} = 4e^{x-y}$ ;  $\frac{\partial f}{\partial y} = -4e^{x-y}$   
 13.  $\frac{\partial f}{\partial x} = \ln y$ ;  $\frac{\partial f}{\partial y} = \frac{x}{y}$   
 15.  $\frac{\partial f}{\partial x} = \frac{2x+3y}{x^2+3xy}$ ;  $\frac{\partial f}{\partial y} = \frac{3x}{x^2+3xy}$   
 17.  $\frac{\partial f}{\partial x} = \frac{4x}{y^2+1}$ ;  $\frac{\partial f}{\partial y} = -\frac{4x^2y}{(y^2+1)^2}$   
 19.  $\frac{\partial f}{\partial x} = \frac{x^2y+6x}{(xy+3)^2}$ ;  $\frac{\partial f}{\partial y} = -\frac{x^3}{(xy+3)^2}$   
 21.  $\frac{\partial f}{\partial x} = 3x^2e^y + 2xye^{x^2}$   
     $\frac{\partial f}{\partial y} = x^3e^y + e^{x^2}$   
 23.  $\frac{\partial f}{\partial x} = \frac{3xy+4}{2\sqrt{xy+2}}$ ;  $\frac{\partial f}{\partial y} = \frac{x^2}{2\sqrt{xy+2}}$   
 25.  $\frac{\partial f}{\partial x} = x^3e^{xy}(xy+4)$ ;  $\frac{\partial f}{\partial y} = x^5e^{xy}$   
 27.  $\frac{\partial f}{\partial x} = \frac{2xy^5}{x^2-5y^2}$   
     $\frac{\partial f}{\partial y} = \frac{-10y^6}{x^2-5y^2} + 5y^4 \ln(x^2-5y^2)$

29.  $\frac{\partial S}{\partial m} = 90m + 22b - 320$

$\frac{\partial S}{\partial b} = 22m + 6b - 80$

31.  $\frac{\partial S}{\partial m} = 562m + 66b - 3494$

$\frac{\partial S}{\partial b} = 66m + 8b - 412$

33.  $f_{xx}(x, y) = 2y^3$

$f_{xy}(x, y) = 3 + 6xy^2$

$f_{yx}(x, y) = 3 + 6xy^2$

$f_{yy}(x, y) = 6x^2y$

35.  $f_{xx}(x, y) = 12x^2y^{\frac{2}{3}}$

$f_{xy}(x, y) = \frac{8}{3}x^3y^{-\frac{1}{3}}$

$f_{yx}(x, y) = \frac{8}{3}x^3y^{-\frac{1}{3}}$

$f_{yy}(x, y) = -\frac{2}{9}x^4y^{-\frac{4}{3}}$

37.  $f_{xx}(x, y) = 0$

$f_{xy}(x, y) = 2e^{2y}$

$f_{yx}(x, y) = 2e^{2y}$

$f_{yy}(x, y) = 4xe^{2y}$

39.  $f_{xx}(x, y) = \frac{160}{9}(4x-3y)^{-\frac{1}{3}}$

$f_{xy}(x, y) = -\frac{40}{3}(4x-3y)^{-\frac{1}{3}}$

$f_{yx}(x, y) = -\frac{40}{3}(4x-3y)^{-\frac{1}{3}}$

$f_{yy}(x, y) = 10(4x-3y)^{-\frac{1}{3}}$

41.  $f_{xx}(x, y) = 0$

$f_{xy}(x, y) = -\frac{15}{(5y+3)^2}$

$f_{yx}(x, y) = -\frac{15}{(5y+3)^2}$

$f_{yy}(x, y) = \frac{50(3x+1)}{(5y+3)^3}$

43.  $f_{xx}(x, y) = \frac{4y^2}{(x-y)^3}$

$f_{xy}(x, y) = -\frac{4xy}{(x-y)^3}$

$f_{yx}(x, y) = -\frac{4xy}{(x-y)^3}$

$f_{yy}(x, y) = \frac{4x^2}{(x-y)^3}$

45.  $f_x(x, y, z) = y + 2z$

$f_y(x, y, z) = x + 9z$

$f_z(x, y, z) = 2x + 9y$

47.  $f_x(x, y, z) = 32x(8x^2 + 5y^2 - 2z^2)$

$f_y(x, y, z) = 20y(8x^2 + 5y^2 - 2z^2)$

$f_z(x, y, z) = -8z(8x^2 + 5y^2 - 2z^2)$

49.  $\frac{\partial F}{\partial x} = 8 + 15y + \lambda$

$\frac{\partial F}{\partial y} = 15x - 4y + \lambda$

$\frac{\partial F}{\partial \lambda} = x + y - 60$

51.  $\frac{\partial F}{\partial x} = 10x + 3y + 14\lambda$

$\frac{\partial F}{\partial y} = 3x - 20y + 17\lambda$

$\frac{\partial F}{\partial \lambda} = 14x + 17y - 49$

53.  $f_L(27, 64) = \frac{640}{9};$

$f_K(27, 64) = 15$

55. a.  $\frac{\partial C}{\partial x} = 7 + 0.06x - y$

b.  $\frac{\partial C}{\partial y} = 5.8 - x + 0.04y$

57. a.  $P(x, y) = 16x + 12y - x^2 + 2xy - 2y^2 - 8$

b.  $P_x(20, 14) = 4; P_y(20, 14) = -4;$   
The marginal profit with respect to model A is \$4 and the marginal profit with respect to model B is -\$4

when 20 units of model A and 14 units of model B are being produced and sold.

59. a.  $P_x(x, y) = 5000 + 10,000y - 1000x$

b.  $P_y(x, y) = 10,000x$

### 16.3 EXERCISES

1.  $f(3, -1) = -14$  is a local minimum.

3.  $(5, 1, -15)$  is a saddle point.

5.  $f\left(\frac{5}{2}, 4\right) = \frac{133}{4}$  is a local maximum.

7.  $(1, -2, -3)$  is a saddle point.

9.  $f(-2, -1) = -18$  is a local minimum.

11.  $f(2, 2) = -3$  is a local minimum.

13.  $f(1, -2) = 13$  is a local maximum.

15.  $f(1, 3) = 0$  is a local minimum;  $(-1, 3, 4)$  is a saddle point.

17.  $(2, 5, 7)$  is a saddle point;  $f(2, 1) = -25$  is a local minimum.

19.  $(2, 1, 8)$  is a saddle point;  $(-2, -1, -8)$  is a saddle point.

21.  $f(0, 0) = 0$  is a local minimum;  $(2, 2, 4)$  is a saddle point;  $(-2, 2, 4)$  is a saddle point.

23.  $f(1, 2) = 6$  is a local minimum.

25. 30 of model X, 25 of model Y

27. 200 of the \$50 racks, 240 of the \$45 racks

29. \$16 for the adult T-shirt, \$13 for the youth T-shirt

31. 9 inches by 6 inches by 3 inches

### 16.4 EXERCISES

1.  $f(2, 2) = 8$       3.  $f(1, -1) = 7$

5.  $f(9, 6) = 612$       7.  $f(4, 4) = 128$

9.  $f(5, 2) = 30$       11.  $f(4, 5) = 112$

13.  $f(5, 2) = 69$       15.  $f(8, 15) \approx 175$

17.  $f(6, 3) = f(-6, -3) = 72$  is a maximum;  
 $f(6, -3) = f(-6, 3) = -72$  is a minimum

19.  $f(12, -6) = 864$  is a maximum;  
 $f(4, 2) = 96$  is a minimum

21. 3 units in LA, 37 units in OKC

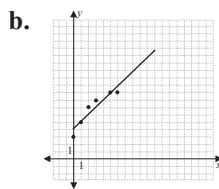
23. approximately 3605 units

25. 10 days in each area

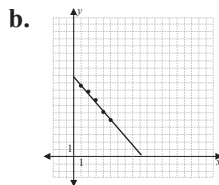
27. 69 feet by 36 feet with the interior lanes 36 feet long

### 16.5 EXERCISES

1. a.  $y = 0.96x + 4.1$



3. a.  $y = -1.18x + 10.96$



5.  $y = -0.12x + 8.19$

7.  $y = 14.7x + 221.9$

9.  $y = 1.1x + 4.02$

11. a.  $y = 3.77x + 21.91$

- b. 37,000 units

13. a.  $y = 11.17x + 4.07$

- b. \$82,260

15. a.  $y = -0.663x + 76.04$

- b. 71.40 cents per pound

### 16.6 EXERCISES

1.  $\frac{3}{2}$                       3.  $\frac{117}{2}$

5.  $5\ln 2 \approx 3.47$       7.  $\frac{320}{3}$

9.  $e^3 - e^2 - e + 1 \approx 10.98$

11.  $\frac{4}{3}$                       13. 56

15.  $\frac{1}{2}(e^{11} - e^8 - e^3 + 1) \approx 28,437.05$

17.  $\frac{288}{5}$                       19.  $\frac{508}{21}$

21.  $\frac{26}{3}$                       23.  $\frac{98}{3}$

25.  $\frac{1}{6}$                       27.  $\frac{31}{60}$

29.  $\frac{e^6}{3} - e^2 + \frac{2}{3} \approx 127.75$

31.  $\frac{3}{20}$                       33.  $\frac{5}{3}$

35. 34                      37.  $\frac{32}{3}$

39.  $\frac{1}{3}$