

# Answer Key

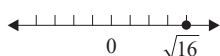
## Chapter 0: Algebra Review

### 0.1 EXERCISES

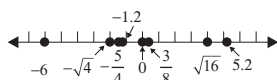
1.  $\{0, \sqrt{16}\}$



3.  $\{\sqrt{16}\}$



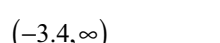
5.  $\left\{-6, -\sqrt{4}, -\frac{5}{4}, -1.2, 0, \frac{3}{8}, \sqrt{16}, 5.2\right\}$



7.  $(-\infty, 7]$



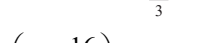
9.  $(-3.4, \infty)$



11.  $(-\infty, 0]$



13.  $(-\infty, \frac{16}{3})$



15.  $(-\infty, \frac{16}{3})$



17. 1.4

21.  $\sqrt{2}$

25. -0.6

29.  $x = \pm \frac{7}{16}$

33.  $x = \pm 3\sqrt{2}$

37. always

41. sometimes

43.  $x = 1$ ; Yes, it is rational.

19.  $\frac{3}{8}$

23. 12

27.  $x = \pm 8$

31.  $\emptyset$

35.  $x \geq 0$

39. sometimes

### 0.2 EXERCISES

1. 343

5. -16

9.  $\frac{1}{x^2}$

13.  $x^7$

17.  $\frac{1}{x^7}$

21.  $y^2$

25.  $\frac{1}{x^3}$

29.  $b^4$

33.  $a^8$

37.  $x^{-5}$

41.  $\frac{1}{3}a^{-2}b^7$

45.  $\frac{27}{8}x^{-3}y^9$

49.  $\frac{1}{25}x^4y^{-2}$

3.  $\frac{1}{36}$

7. -50

11.  $\frac{5}{y}$

15.  $x$

19.  $\frac{1}{a^3}$

23.  $x^5$

27.  $x^3$

31.  $x^6$

35.  $y^{-1}$

39.  $x^{10}$

43.  $\frac{4}{3}x^6y^{-2}$

47.  $\frac{1}{36}s^2t^{-8}$

### 0.3 EXERCISES

1. 4

5.  $\frac{1}{125}$

9. 4

13.  $x^{-\frac{1}{6}}$

17.  $x^{\frac{1}{3}}$

21.  $b^{\frac{3}{10}}$

25.  $x^{\frac{1}{4}}$

29.  $3x^2y^2$

33.  $\sqrt{y}$

3. 8

7. -3

11.  $x^{\frac{5}{2}}$

15.  $a^{\frac{8}{5}}$

19.  $x^{-\frac{7}{4}}$

23.  $s^{\frac{7}{8}}$

27.  $x^{\frac{4}{5}}$

31.  $\frac{2t^{\frac{5}{4}}}{25s^{\frac{1}{6}}}$

35.  $\frac{1}{\sqrt[4]{x}}$

37.  $\sqrt[5]{(x-2)^4}$

41.  $-\frac{2}{7\sqrt[4]{t^2-4}}$

45.  $s^{-\frac{1}{4}}$

49.  $(a^2+2)^{-\frac{1}{3}}$

51.  $\frac{4}{9}x(x+5)^{-\frac{2}{3}}$

53.  $4\sqrt{3}$

57.  $5\sqrt{6x}$

39.  $\frac{2}{\sqrt{y^2+4}}$

43.  $x^{\frac{1}{4}}$

47.  $(y+10)^{\frac{2}{3}}$

55.  $\frac{3}{4}$

59.  $6t\sqrt{3t}$

### 0.4 EXERCISES

1.  $2x^2 + x + 5$

3.  $5a^2 + 14a - 2$

5.  $x^2 + 8x + 2$

7.  $4x^2 + 3x + 11$

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.  $x^3 + 27$

35.  $-7x + 9$

39.  $4x^2 - x$

43.  $(s-7)(s+2)$

45.  $(x+13)(x-2)$

49.  $3(3a-2)(3a+2)$

33.  $x^3 + 8y^3$

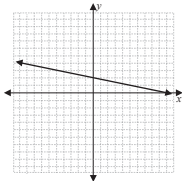
37.  $7t + 7$

41.  $3y, 4, 6$

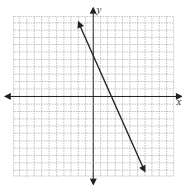
51.  $(x-1)(x+1)(x^2+x+1) \cdot (x^2-x+1)$   
 53.  $(5x^4-4)(5x^4+4)$   
 55.  $2(t+2y)(t^2-2ty+4y^2)$   
 57.  $(s+1)(s-1)(s^2+1)$   
 59.  $100x(y+1)^2$   
 61. Answers will vary.

**0.5 EXERCISES**

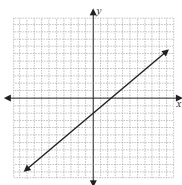
1.  $\frac{1}{3}$       3. 3  
 5.  $-\frac{64}{85}$       7. No  
 9. No  
 11.  $-7x+2y=7$   
 13.  $y=\frac{2}{3}x+3$   
 15.  $2x+5y=14$   
 17.  $y=-\frac{1}{5}x+2; m=-\frac{1}{5}; b=2$



19.  $y=-2x+\frac{11}{2}; m=-2; b=\frac{11}{2}$



21.  $y=\frac{5}{6}x-2; m=\frac{5}{6}; b=-2$



23. No      25. No  
 27. Neither; because the slopes of the lines are neither the same nor negative reciprocals of one another.

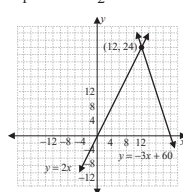
29. Parallel; because the slopes of the lines are the same.  
 31. Perpendicular; because the slopes of the lines are negative reciprocals of one another.  
 33. Neither; because the slopes of the lines are neither the same nor negative reciprocals of one another.  
 35. Perpendicular; because the slopes of the lines are negative reciprocals of one another.

37.  $y=-\frac{1}{3}x+2$

39.  $y=\frac{7}{5}x+\frac{17}{5}$

41.  $y=-\frac{4}{3}x+7$

43.  $b_1=0; b_2=60$



45.  $y=-\frac{1}{10}x+22$

47. \$225      49. \$500

51.  $A=\frac{-b^2}{2m}$

**0.6 EXERCISES**

1.  $x=-3$       3.  $x=2$   
 5.  $x=2$       7.  $x=2$   
 9.  $y=-1$       11.  $t=-1$   
 13.  $x=-0.12$       15.  $x=4$   
 17.  $x=0$       19.  $y=0$   
 21.  $x=-2$       23.  $y=-6$   
 25.  $n=6$       27.  $n=8$   
 29.  $x=0$       31.  $x=-7$   
 33.  $x=-\frac{1}{8}$       35.  $x=-\frac{13}{2}$   
 37.  $x=-\frac{21}{5}$       39.  $x=-\frac{8}{15}$   
 41.  $y=\frac{28}{5}$       43.  $x=2$

45.  $y=\frac{7}{5}$       47.  $x=-4.5$

49.  $x=-44$       51.  $x=2$

53.  $x=-4$       55.  $y=0.5$

57.  $x=1.5$       59.  $x=0.2$

61.  $x=-5$       63.  $n=3$

65.  $y=6$       67.  $x=3$

69.  $n=0$       71.  $y=0$

73.  $z=-1$       75.  $y=\frac{1}{5}$

77.  $x=-3$       79.  $x=-4$

81.  $x=-21$       83.  $y=0$

85.  $y=1$       87.  $x=-\frac{3}{2}$

89.  $x=\frac{1}{4}$       91.  $x=\frac{3}{17}$

93.  $x=-\frac{1}{4}$       95.  $x=\frac{8}{5}$

97.  $x=\frac{2}{3}$       99.  $x=6$

101.  $x=-11$       103.  $x=\frac{1}{2}$

105.  $x=-5$       107.  $n=-1.5$

109.  $x=0$

111. Conditional

113. 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

### 0.7 EXERCISES

1.  $\left\{\frac{3}{2}, -1\right\}$
5.  $\left\{-\frac{3}{2}, -3\right\}$
9.  $\{2\}$
13.  $\{0, 6\}$
17.  $\left\{-\frac{5}{3}, \frac{1}{3}\right\}$
21.  $\left\{\frac{6}{5}, 6\right\}$
25.  $\left\{-\frac{7}{2}, \frac{9}{2}\right\}$
29.  $\{-25, -1\}$
33.  $\{-1\}$
37.  $\left\{-\frac{3}{2}, 5\right\}$
41.  $\{2, 14\}$
45.  $\{-16, 12\}$
49.  $\{0, 6\}$
53.  $\left\{1, 2, \frac{3 \pm \sqrt{17}}{2}\right\}$
55.  $(3x - 1 - \sqrt{5})(3x - 1 + \sqrt{5})$
3.  $\{7\}$
7.  $\{-3, 1\}$
11.  $\{3, 11\}$
15.  $\left\{\frac{-1 \pm \sqrt{7}}{2}\right\}$
19.  $\{-5, 9\}$
23.  $\{-5, 2\}$
27.  $\left\{\frac{13}{2}, \frac{15}{2}\right\}$
31.  $\left\{-\frac{4}{3}, 1\right\}$
35.  $\left\{\frac{-1 \pm \sqrt{13}}{6}\right\}$
39.  $\{-14, -6\}$
43.  $\left\{\frac{-1 \pm \sqrt{7}}{2}\right\}$
47.  $\{-7, -6\}$
51.  $\{-1, 2\}$

57.  $b = -5$  and  $c = -24$

### 0.8 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.  $x = \frac{1}{4}$
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.  $\{0\}$
43.  $\emptyset$
47.  $\emptyset$
51.  $\{1\}$
55.  $\emptyset$
59.  $\{0, 5\}$
63.  $\{2\}$
67.  $\left\{\pm \frac{125}{343}\right\}$
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 1: Functions, Models, and Graphs

### 1.1 EXERCISES

1. a. 3      b. -11  
c.  $a - 5$       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

**1.2 EXERCISES**

1. a. 3      b.  $\frac{7}{9}$   
 c.  $-\frac{20}{9}$       d.  $-\frac{10}{9}$   
 e. a. and b. are y-values of points on the graph of  $f$ ; c. is the change in  $y$ , which is the vertical distance between  $f(3)$  and  $f(1)$ ; d. is the difference quotient, which gives the slope of the line that passes through the points  $(1, f(1))$  and  $(3, f(3))$ .
3.  $\frac{1}{x} + x^2 - 2x$       5.  $\frac{\sqrt{x}}{x}$   
 7.  $x\sqrt{x}$       9.  $-1$   
 11.  $\sqrt{3}$       13.  $\frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}$   
 15.  $t^2 - 1$       17.  $\sqrt{2t-1}$   
 19.  $\frac{1}{x^2} - \frac{2}{x}$       21.  $x - 2\sqrt{x}$   
 23.  $\frac{1}{\sqrt{u}} = \frac{\sqrt{u}}{u}$   
 25.  $g(x) = \sqrt[3]{x}, h(x) = 1 - 6x^2$   
 27.  $g(x) = x^{\frac{1}{3}}, h(x) = x^4 + 2$   
 29.  $g(x) = \frac{\sqrt{x}}{x^2}, h(x) = x - 3$

**1.3 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.  $A(x) = 360x - \frac{3}{2}x^2$   
 57. 100 hot dogs

**1.4 EXERCISES**

1.  $1 + 3x + x^2(1 + 2)$   
 3.  $(3x) \div (x - 1)^2(1 + 2)$

5.  $(-3x + 16)^4 \div (3x + 6)$   
 7.  $(2x^2 \div 3 + 3x^2 \div 5 + 3)^5$   
 9. The standard window displays a graph that is not informative. A window of  $[-10, 10]$  by  $[-14, 6]$  is better.  
 11. The standard window does not display the graph on the screen. A window of  $[-10, 10]$  by  $[-10,000, 210,000]$  is better.  
 13. In the standard window, the curve is split into two parts. A window of  $[-10, 10]$  by  $[-500, 500]$  is better.  
 15. In the standard window, the curve is split into two parts. A window of  $[-10, 10]$  by  $[-500, 500]$  is better.  
 17. The standard window does not closely display the interesting part of the graph. A window of  $[-5, 5]$  by  $[-5, 5]$  is better.  
 19. The standard window does not closely display the interesting part of the graph. A window of  $[-5, 5]$  by  $[-5, 5]$  is better.  
 21. In the standard window, the curve is split into two parts. A window of  $[-10, 10]$  by  $[-100, 100]$  is better.

23.

$x$	$y$
-2	48
-1	11
0	10
2	-28

Zeros in the given  $x$ -interval:  
 $x \approx 1.417$

25.

$x$	$y$
-2	-3.826
-1	undefined
0	0
2	-0.962

Zeros in the given  $x$ -interval:  
 $x = 0, 5$

27.

$x$	$y$
-2	990
-1	472
0	210
2	70

Zeros in the given  $x$ -interval:  $x = 3$

29.

$x$	$y$
-2	undefined
-1	undefined
0	1.732
2	5.469

Zeros in the given  $x$ -interval:  $\emptyset$

31.  $y_{\min} = 20$  at  $x = 52$

33.  $y_{\min} = -21.98$  at  $x = 2.38$

35.  $y_{\min} = -90.85$  at  $x = 28.44$

37.  $y_{\min} = -236.50$  at  $x = 6.17$

39.  $y_{\min} = -130,783$  at  $x = 2$

## Chapter 2: Limits and the Derivative

### 2.1 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,  $4\sqrt{3}$ , 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

21. a. yes    b. yes    c. yes

### 2.3 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

### 2.2 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. 1    b. 3

c. does not exist

d. -3    e. -3    f. -3

9. a.  $+\infty$     b.  $-\infty$     c. 2    d. 0

11. a.  $+\infty$     b. 3

c. does not exist    d. 0

13. 2

15. 12

17. 6

19. 32

### 2.4 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.,

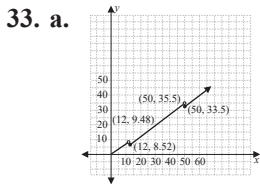
$$\lim_{x \rightarrow 0} f(x) = f(0).$$

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.

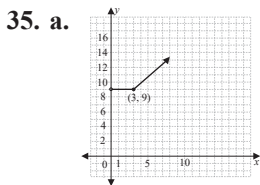
13.  $f(x)$  is continuous at  $x = 1$ .  
 15.  $f(x)$  is discontinuous at  $x = 2$ .  
 17.  $f(x)$  is continuous at  $x = 1$ .  
 19.  $f(x)$  is discontinuous at  $x = 0$ .

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  $x > 0$ .

### 2.5 EXERCISES

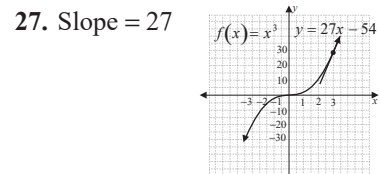
1.  $-2.5$       3.  $-1$   
 5.  $5$       7.  $8$   
 9.  $0.1333$       11.  $0.3874$   
 13.  $\frac{2 + 2h - \sqrt{4 + h}}{h}$   
 15. a. In the year 2000, the population was 250 million.  
 b. 257.8 million  
 c. 0.78 million/year  
 17. a. 38.56 barrels  
 b. 4.76 barrels/hr

### 2.6 EXERCISES

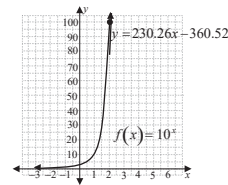
1.  $f'(15) = 1$   
 3. 12:00 p.m.  
 5.  $f(3) = 14$ : 14 is the value of the function at the point  $x = 3$ .  
 $f'(3) = 7$ : 7 is the slope of the tangent line at  $x = 3$ .  
 7.  $f'(s)$  is the rate of spending per customer for  $s$  customers.  
 9.  $f'(x)$  is the rate of change of cost per 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 means 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.



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

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

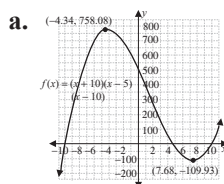
33.

$x$	$y$	$y$ -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.  $(\frac{1}{4}, \frac{1}{2})$

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

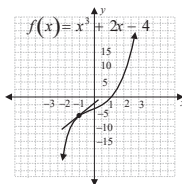
### 2.7 EXERCISES

- 1. 0
- 3. -1
- 5.  $1 - 2x$
- 7.  $3x^2$
- 9.  $\frac{1}{x^2}$
- 11. 0
- 13. 7
- 15. -1
- 17.  $8x$
- 19.  $-\frac{7}{x^2}$
- 21.  $-\frac{3}{2x^4}$
- 23.  $\frac{3}{2\sqrt{x}}$

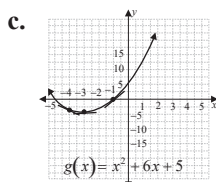
25.  $2.3t^{1.3}$       27.  $2.4x^{-0.2}$   
 29.  $-\frac{1}{2}u^{-\frac{3}{2}}$       31.  $-\frac{15}{4}x^{-\frac{1}{4}}$

### 2.8 EXERCISES

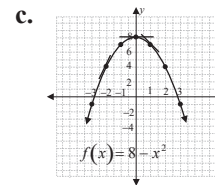
- 1.  $3x^2 - 7$
- 3.  $0.6x - 4$
- 5.  $3x^2 - 12x + 5$
- 7.  $3x^{\frac{1}{2}} + 2x^{-\frac{1}{2}}$
- 9.  $-t^{-\frac{3}{2}} + \frac{1}{2}t^{-\frac{1}{2}} + 1$
- 11.  $y = 2x^2 - x - 3$ ,  
 $y' = 4x - 1$
- 13.  $f(v) = v^{\frac{7}{2}} + 2v^{\frac{5}{2}} - v^{\frac{3}{2}}$ ,  
 $f'(v) = \frac{7}{2}v^{\frac{5}{2}}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

### 2.9 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.  $C'(x) = 28 + 0.5x$   
 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.  $\bar{C}'(4) = -4.25,$   
 $\bar{C}'(6) = -2.17,$   
 $\bar{C}'(9) = -1.24$
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. a.  $H'(t) = \frac{-10.4t^3}{10^6} + \frac{5.61t^2}{10^4}$   
 $-0.00792t + 0.116$   
 b.  $H(30) = 8.909$  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 3: More about the Derivative

### 3.1 EXERCISES

1.  $f'(x) = -8x^3 + 9x^2 + 2x$
3.  $f'(x) = \frac{15x^2 + 1}{2\sqrt{x}}$
5.  $f'(x) = 8x$
7.  $g'(x) = -\frac{1}{x^{\frac{3}{2}}}$
9.  $g'(x) = 6 - 10x^4$
11.  $5x^2(x^2 + 3)$
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.  $h'(2) = 1$

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

39.  $h'(2) = \frac{129}{256}$

41.  $h'(2) = \frac{1}{3}$

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

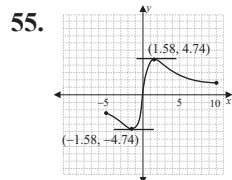
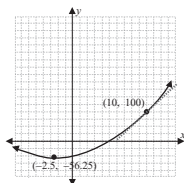
45.  $y = 616.5x - 1766$

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

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

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

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



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

57. \$1.15/item

59. \$13.20/item

61. 6100 people/year

### 3.2 EXERCISES

1.  $8(2x - 5)^3$

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.  $\frac{3x^2}{2\sqrt{x^3 + 1}}$

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

23.  $\frac{8}{(t^2 + 8)^{\frac{3}{2}}}$

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

27.  $\frac{18x - 13}{2(3x - 4)^{\frac{1}{2}}}$

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

b. \$5880

c.  $40\sqrt{70 - x} - \frac{20x}{\sqrt{70 - x}}$

d. \$220 per oven

63. a. 18,560 people

b. 640 people/year

65. 218 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 2010.

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 2020.

### 3.3 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.  $\frac{dy}{dx} = \frac{4x^{\frac{3}{2}}y^{\frac{1}{2}} + y}{8x^{\frac{1}{2}}y^{\frac{3}{2}} - x}$

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.  $\frac{dy}{dx} = \frac{20x^2y^{\frac{1}{2}} - y}{4x^{\frac{1}{2}}y^{\frac{1}{2}} + x}; m = \frac{76}{9}$

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.  $\frac{dy}{dt} = \frac{2(x+y)}{3y^2-2x} \frac{dx}{dt}$

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.  $-\frac{45}{8}$  ft/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.  $\left. \frac{dy}{dt} \right|_{t=t_0} = 37.5$  mph

59. a.  $S = 12$

b.  $\frac{dp}{dn} = -\frac{p-p^2}{n(1-2p)}; -0.00049$

### 3.4 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.  $(-2, -1), (2, +\infty)$

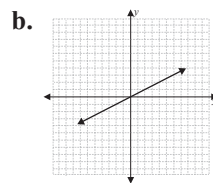
b.  $(-\infty, -2), (-1, 2)$

9. a.  $(-\infty, -2), (0, 6)$

b.  $(-2, 0), (6, +\infty)$

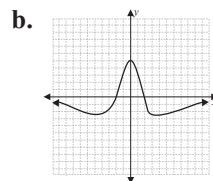
11. a. Inc.:  $(0, +\infty);$

Dec.:  $(-\infty, 0)$



13. a. Inc.:  $(-2, 2);$

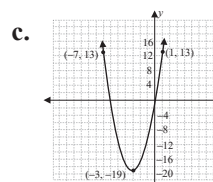
Dec.:  $(-\infty, -2), (2, +\infty)$



15. a.  $x = -3$

b. Inc.:  $(-3, +\infty);$

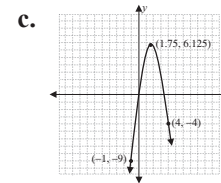
Dec.:  $(-\infty, -3)$



17. a.  $x = \frac{7}{4}$

b. Inc.:  $(-\infty, \frac{7}{4});$

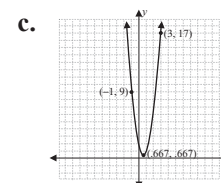
Dec.:  $(\frac{7}{4}, +\infty)$



19. a.  $x = \frac{2}{3}$

b. Inc.:  $(\frac{2}{3}, +\infty);$

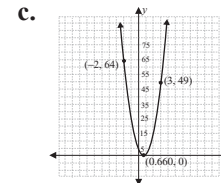
Dec.:  $(-\infty, \frac{2}{3})$



21. a.  $x = \frac{2}{3}$

b. Inc.:  $(\frac{2}{3}, +\infty);$

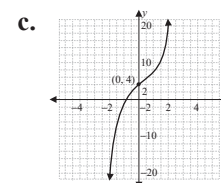
Dec.:  $(-\infty, \frac{2}{3})$



23. a.  $x = 0$

b. Inc.:  $(-\infty, +\infty);$

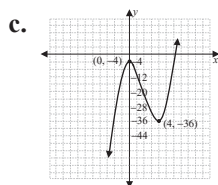
Dec.:  $\emptyset$



25. a.  $x = 0, x = 4$

b. Inc.:  $(-\infty, 0), (4, +\infty);$

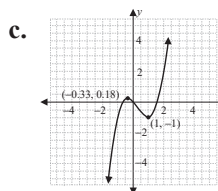
Dec.:  $(0, 4)$



27. a.  $x = -\frac{1}{3}, x = 1$

b. Inc.:  $(-\infty, -\frac{1}{3}), (1, +\infty)$ ;

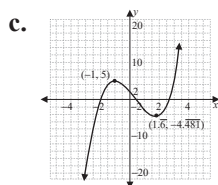
Dec.:  $(-\frac{1}{3}, 1)$



29. a.  $x = -1, x = \frac{5}{3}$

b. Inc.:  $(-\infty, -1), (\frac{5}{3}, +\infty)$ ;

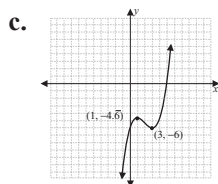
Dec.:  $(-1, \frac{5}{3})$



31. a.  $x = 1, x = 3$

b. Inc.:  $(-\infty, 1), (3, +\infty)$ ;

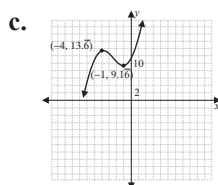
Dec.:  $(1, 3)$



33. a.  $x = -1, x = -4$

b. Inc.:  $(-\infty, -4), (-1, +\infty)$ ;

Dec.:  $(-4, -1)$



35. a. None

b. Inc.:  $\emptyset$ ;

Dec.:  $(-\infty, 2), (2, +\infty)$

37. a. None

b. Inc.:  $(-\infty, 0), (0, +\infty)$ ;

Dec.:  $\emptyset$

39. a.  $x = -3$

b. Inc.:  $(-\infty, -3), (0, +\infty)$ ;

Dec.:  $(-3, 0)$

41. a. None

b. Inc.:  $(-\infty, -3), (-3, +\infty)$ ;

Dec.:  $\emptyset$

43. a.  $x = 4$

b. Inc.:  $(4, +\infty)$ ;

Dec.:  $(-\infty, 0), (0, 4)$

45. Inc.:  $(0, 8000)$ ;

Dec.:  $(8000, 10,000)$

47. Inc.:  $(0, 62.5)$ ;

Dec.:  $(62.5, 100)$

49. 4 years

51.  $\bar{C}(x) = \frac{250}{x} + 45 - 0.2x$ ;

$\bar{C}'(x) = -0.2 - \frac{250}{x^2} < 0$

b. local max:  $f(-3) = -6$ ;

local min:  $f(3) = 6$

15. a. No critical values

b. No local extrema

17. a.  $x = -\frac{1}{3}, x = \frac{1}{3}$

b. local max:  $f(-\frac{1}{3}) = -6$ ;

local min:  $f(\frac{1}{3}) = 6$

19. a.  $x = \frac{1}{2}$

b. local min:  $f(\frac{1}{2}) = 12$

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  $v = 5.2$

### 3.5 EXERCISES

1. a.  $x = 2$

b. local max:  $f(2) = 4$

3. a.  $x = -3$

b. local min:  $f(-3) = -11$

5. a.  $x = 4$

b. local min:  $f(4) = -5$

7. a.  $x = -1, x = \frac{1}{3}$

b. local max:  $f(-1) = 4$ ;

local min:  $f(\frac{1}{3}) = \frac{76}{27}$

9. a.  $x = -3, x = 2$

b. local max:  $f(2) = 28$ ;

local min:  $f(-3) = -\frac{69}{2}$

11. a.  $x = -1, x = 1$

b. local max:  $f(-1) = 8$ ;

local min:  $f(1) = 4$

13. a.  $x = -3, x = 3$

### 3.6 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;

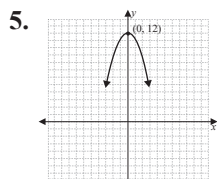
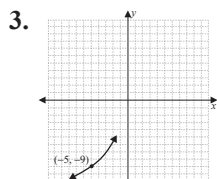
$f(0) = 0$  max

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. 250 shirts
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 4: Applications of the Derivative

### 4.1 EXERCISES

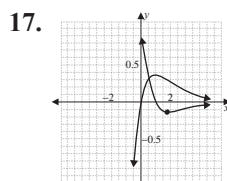
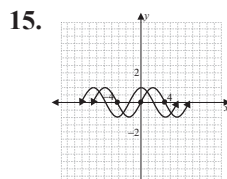
1. At A:  $f'$  is positive;  $f''$  is positive  
At B:  $f'$  is positive;  $f''$  is zero  
At C:  $f'$  is zero;  $f''$  is negative  
At D:  $f'$  is negative;  $f''$  is zero  
At E:  $f'$  is negative;  $f''$  is positive



7.  $f''(x) = 6x - 2$ ;  
 $f''(0) = -2$ ;  $f''(1) = 4$ ;  
 $f''(4) = 22$

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

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.  $\left(-\infty, \frac{3}{5}\right)$  b.  $\left(\frac{3}{5}, +\infty\right)$

- c.  $\left(\frac{3}{5}, 0\right)$

33. a.  $(-\sqrt{5}, 0)$ ,  $(\sqrt{5}, \infty)$   
b.  $(-\infty, -\sqrt{5})$ ,  $(0, \sqrt{5})$   
c.  $(0, 0)$

35.  $G(x) = x^4$  37.  $J(x) = (x - 4)^3$

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

$$f''(x) = 6x - \frac{1}{3x^{\frac{3}{2}}}$$

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:  $(0, 0), \left(-\sqrt{3}, \frac{-3\sqrt{3}}{4}\right),$

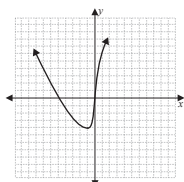
$$\left(\sqrt{3}, \frac{3\sqrt{3}}{4}\right);$$

Con. up:  $(-\sqrt{3}, 0), (\sqrt{3}, +\infty)$ ;

Con. down:  $(0, \sqrt{3}), (-\infty, -\sqrt{3})$

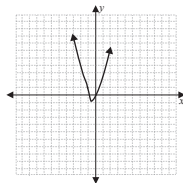
13. POI:  $(2.5, 10.179), (0, 0)$ ;

$$\text{min: } \left(-\frac{5}{4}, -4.04\right)$$



15. POI:  $(-1, 0), (-1.5, 2.38)$ ;

$$\text{min: } \left(-\frac{3}{4}, -0.94\right)$$



17. Local min:  $f\left(\frac{3}{2}\right) = \frac{11}{4}$

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:

$$f\left(-\frac{3}{2}\right) = -\frac{91}{16}$$

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  $x = 0$

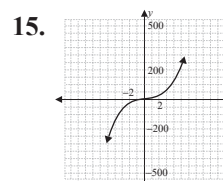
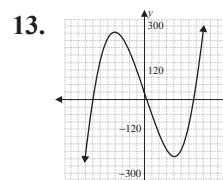
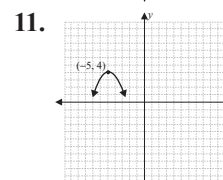
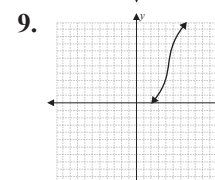
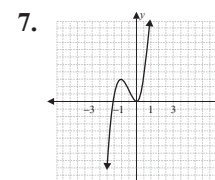
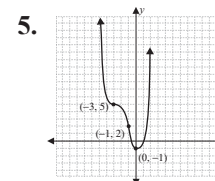
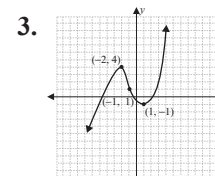
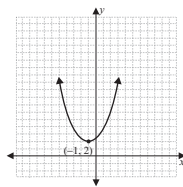
b. Max/min can exist; POI at  $x = 0$

c. No

d. Answers will vary.

### 4.3 EXERCISES

1.



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

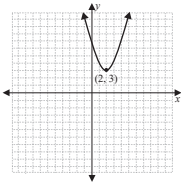
17.  $(-\infty, 2)$ ;  $f'(x) < 0$ ; Decreasing  
 $(2, +\infty)$ ;  $f'(x) > 0$ ; Increasing

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

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

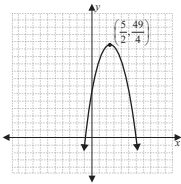
Decreasing

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

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

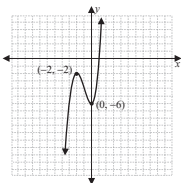
$(-\infty, -1); f''(x) < 0;$

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

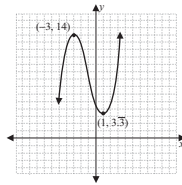
$(-\infty, -1); f''(x) < 0;$

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

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

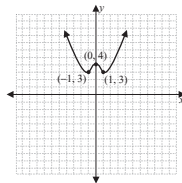
$f''(x) > 0;$  Concave up

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

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

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

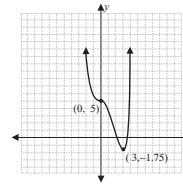
Concave up

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

Concave down

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

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



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

Decreasing

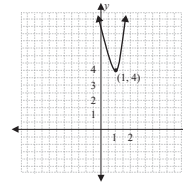
$(1, +\infty); f'(x) > 0;$

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.;

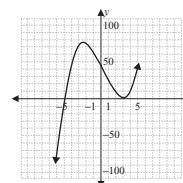
$(-\infty, \frac{1}{3}); f''(x) < 0;$

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  $x = 8;$

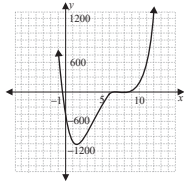
Increasing;

$x = 1.62; f'(1.62) = 0;$  Local min.;

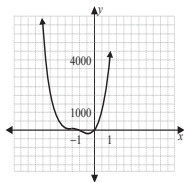
$(-\infty, 3.75), (8, +\infty); f''(x) > 0;$

Concave up;

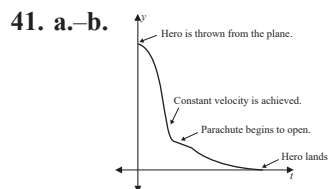
$(3.75, 8); f''(x) < 0$ ; Concave down;  
 $x = 3.75, f''(3.75) = 0$ ; POI;  
 $x = 8; f''(8) = 0$ ; POI



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

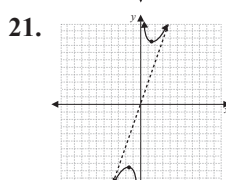
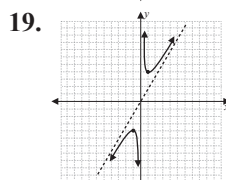
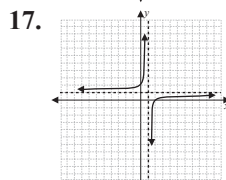
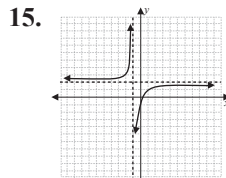
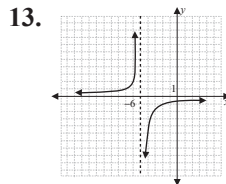


43. a. at  $x = 5$   
 b. The workers should do the most demanding work starting 1 hour and 15 min. after their arrival to 7 hours and 15 min. into their work day. The first 1 hour and 15 min. and the last 45 min. of their day should be spent on the easier tasks. Doing so will achieve a PR of 25.02.

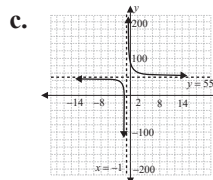
**4.4 EXERCISES**

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.  $y = \frac{5}{3}$

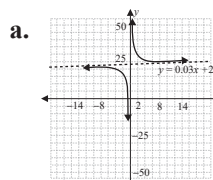
- c. None  
 9. a.  $x = 0$    b. None   c.  $y = x$   
 11. a.  $x = -1$    b. None   c.  $y = x - 1$



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. 20 million dollars

**4.5 EXERCISES**

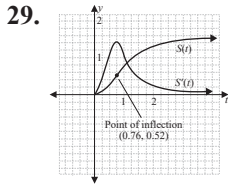
1. 25 vacuum cleaners per order;  
 5 orders per year  
 3. 30 copies per order; 3 orders per year  
 5. 200 sweatshirts per order;  
 20 orders per year  
 7. 120 snowmobiles per order;  
 8 orders per year  
 9. \$24                      11. 75 cents  
 13. 5 salespeople  
 15. \$6  
 17. 13 units 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  $V''$ ).



#### 4.6 EXERCISES

- 4 in. by 4 in.
- $\frac{5}{3}$  in. by  $\frac{14}{3}$  in. by  $\frac{35}{3}$  in.
- a. 12 in. by 12 in. by 6 in.  
b. 432 in.<sup>2</sup>
- 2 ft by 2 ft by 2.5 ft
- 1.82 ft

- 18.5 ft by 37 ft
- 70 ft by 70 ft; 4900 ft<sup>2</sup>
- 36 ft by 69 ft
- $\frac{65}{3}$  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
- 3 miles from point A
- 0.8 miles from point A
- a. 67 ft/sec b. 129 ft/sec  
c. 144 ft/sec

#### 4.7 EXERCISES

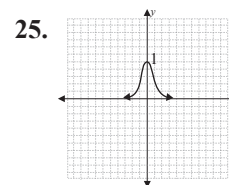
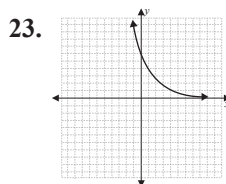
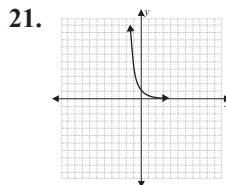
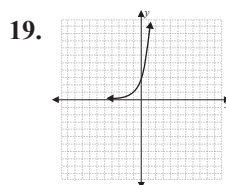
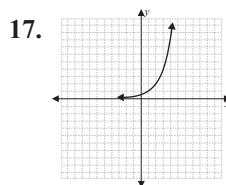
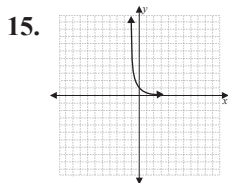
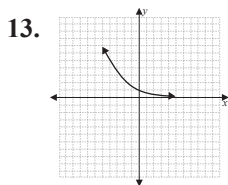
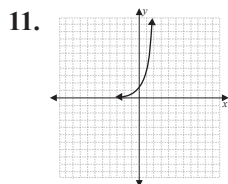
- $dy = 3x^2 dx$
- $du = 8t(2t^2 + 1) dt$

- $dA = 2\pi r dr$
- $dV = 4\pi r^2 dr$
- $dS = \left(8x - \frac{1350}{x^2}\right) dx$
- $dC = \left(3 + \frac{0.2}{\sqrt{x}}\right) dx$
- $dP = (75 - 0.4x) dx$
- a. 0.64 b. 0.6 c. 0.04
- a. 14.03 b. -15.36 c. 1.33
- a. -17.7 b. -16.8 c. -0.9
- a. 0.148 b. 0.15 c. -0.002
- $6 + \frac{1}{12}$       25.  $3 - \frac{1}{27}$
- $7 + \frac{1}{10}$       29.  $4 - \frac{17}{480}$
- \$20.40      33. \$42
- 340 people      37. 19.44 in.<sup>3</sup>
- 0.013 ft      41. 2400 $\pi$  in.<sup>3</sup>

## Chapter 5: Exponential and Logarithmic Functions

#### 5.1 EXERCISES

- 199.53      3. 0.61
- 20.09      7. 0.40
- a. 1 b. 3 c. 27



- a. \$6312.38 b. \$6333.85  
c. \$6344.93 d. \$6356.12  
e. \$6356.25
- \$8481.89
- The 8 percent investment is better by \$88.43.
- 0.82 mg
- 225,594 people
- \$3168.06
- \$15,059.71

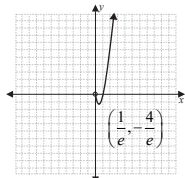
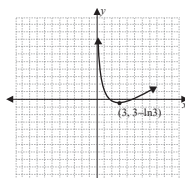
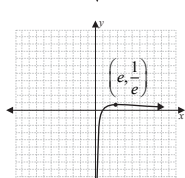
#### 5.2 EXERCISES

- $\ln(1.648721) \approx 0.5$
- $\ln(0.122456) \approx -2.1$
- $\ln(1.284025) \approx 0.25$

- 7.  $e^{0.6} \approx 1.822119$
- 9.  $e^{3.161247} \approx 23.6$
- 11.  $e^{-2.6670} \approx 0.069460$
- 13. 4.6                      15. 3
- 17.  $\frac{1}{3}$                         19.  $5x$
- 21.  $2t-1$                 23.  $\ln(xy^3)$
- 25.  $\ln\left(\frac{xz}{y}\right)$
- 27.  $\ln(x(x+3))$
- 29.  $\ln\left(\frac{x^2}{x+1}\right)$       31.  $\ln(x-1)$
- 33.  $\ln\left(\frac{(x+3)(x+1)}{x^{\frac{1}{2}}}\right)$
- 35.  $3\ln x + 2\ln y$
- 37.  $\frac{1}{3}(\ln x - \ln y)$
- 39.  $\ln 15 + \ln x - \frac{1}{2}\ln y$
- 41.  $\frac{1}{2}\ln(4x+1)$
- 43.  $1 - 2\ln(x+2)$
- 45.  $\ln(x+4) + \ln(x-4)$
- 47.  $-\frac{1}{2} + \frac{\ln 13}{2} \approx 0.7825$
- 49.  $-\frac{\ln(0.8)}{0.6} \approx 0.3719$
- 51.  $\frac{\ln 18}{\ln 5} \approx 1.7959$
- 53.  $\frac{1}{3}\left(1 + \frac{\ln(8.6)}{\ln 10}\right) \approx 0.6448$
- 55. 3                        57.  $\sqrt{2}$
- 59.  $1+e \approx 3.7183$
- 61. a. 7.56 years    b. 7.31 years  
c. 7.25 years
- 63. 8.66 years      65. 3.98 years
- 67. a. \$36,725.89, \$73,377.52,  
\$80,670.38  
b. \$86,836.41  
c. 17,456 books

### 5.3 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.  $\frac{dy}{dx} = \frac{1}{\ln 3} \cdot \frac{1}{x}$
- 23.  $\frac{dy}{dx} = \frac{3}{\ln 10} + 3 \log x$
- 25.  $f'(x) = \frac{9x^2+2x+9}{(3x+1)(x^2+3)}$
- 27.  $f'(x) = \frac{8x^2-2x-8}{(2x-1)(x^2-2)}$
- 29.  $\frac{dy}{dx} = -\frac{3}{(x+1)(x-2)}$
- 31.  $f'(x) = \frac{2x^2+18x+10}{(x^2-5)(2x+9)}$
- 33.  $f''(x) = \frac{2 - \ln x}{x(\ln x)^3};$   
 $x = e^2 \approx 7.39; (e^2, 3.7)$
- 35.  $f''(x) = 9 + 6\ln x;$   
 $x = e^{-\frac{3}{2}}; (e^{-\frac{3}{2}}, -0.224)$
- 37.  $f''(x) = \frac{3\ln x}{x^2}[2 - \ln x];$   
 $x = 1, x = e^2 \approx 7.39;$   
 $(1, 0), (e^2, 8)$

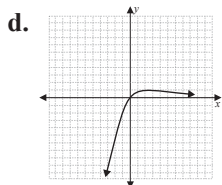
- 39.  $\frac{dy}{dx} = \frac{(2x-5)^2(8x^2-19x+5)}{\sqrt{x^2-2x}}$
- 41.  $\frac{dy}{dx} = \frac{2x(11x^2-14)(x^2+2)^3}{3(x^2-1)^{\frac{4}{3}}}$
- 43.  $\frac{dy}{dx} = \frac{(16x^2-46x-54)(2x+x^2)^2}{(4x-9)^3}$
- 45.  $\frac{dy}{dx} = \frac{(21x^2-114x-248)(x+2)(3x+4)}{2(x-6)^{\frac{3}{2}}}$
- 47. Abs. max.: (2, 1.31);  
Abs. min.: (1, 1)
- 49. Abs. max.: (1.2, 6.58);  
Abs. min.: (e, e)
- 51. Abs. max.: (e, 4.39);  
Abs. min.: ( $\sqrt{1.5}, 0.89$ )
- 53. 
- 55. 
- 57. 
- 59.  $96 + \frac{8x}{4x^2+15}$  dollars per table
- 61. \$294.30
- 63. a. 54 flies, 61 flies, 0 flies  
b. 63 flies

### 5.4 EXERCISES

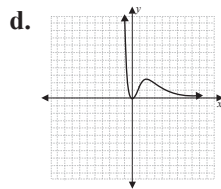
- 1.  $f'(x) = f''(x) = 3e^x$
- 3.  $f'(x) = 2x + 5e^x$   
 $f''(x) = 2 + 5e^x$
- 5.  $f'(x) = e^x(x+1)$   
 $f''(x) = e^x(x+2)$

7.  $f'(x) = \ln 9 \cdot 9^x$   
 $f''(x) = (\ln 9)^2 \cdot 9^x$
9.  $f'(x) = e^x \left( \frac{1}{x} + \ln x \right)$   
 $f'(1) = e$
11.  $f'(x) = -\frac{e^x}{(e^x - 1)^2}$   
 $f'(2) = -0.181$
13.  $f'(x) = 8e^{4x}$   
 $f'(-1) = 0.147$
15.  $f'(x) = 6e^{2x+1}$   
 $f'(0) = 6e \approx 16.310$
17.  $f'(x) = -2 \ln 10 \cdot \left( \frac{10^x}{x^2} \right)$   
 $f'(2) = -5 \ln 10 \approx -11.513$
19.  $f'(x) = -2xe^{1-x^2}$ ;  
 inc. on  $(-\infty, 0)$ ; dec. on  $(0, \infty)$
21.  $f'(x) = 4e^{2x}(e^{2x} - 4)$ ;  
 dec. on  $(-\infty, 0.693)$ ;  
 inc. on  $(0.693, \infty)$
23.  $f'(x) = \frac{-0.1e^{-0.2x}}{(e^{-0.2x} + 11)^{\frac{1}{2}}}$ ;  
 always decreasing;  
 horiz. asym.:  $y = \sqrt{11}$
25.  $f'(x) = \frac{e^x}{e^x + 1}$ ; There  
 is an oblique asym. since  
 $f'(x) \rightarrow 1$  as  $x \rightarrow \infty$ .
27. Abs. min.:  $(-0.5, -0.18)$ ;  
 Abs. max.:  $(1, 7.39)$
29. Abs. min.:  $(0, 0)$ ;  
 Abs. max.:  $(-1, e)$
31. Abs. min.:  $(-2, 0.25)$ ;  
 Abs. max.:  $(0, 13.59)$
33. Abs. min.:  $(1, 4.09)$ ;  
 Abs. max.:  $(3.5, 4.97)$
35. a.  $x = 2.5$  b.  $x = 5$

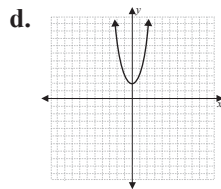
c. up:  $(5, \infty)$ ; down:  $(-\infty, 5)$



37. a.  $x = 0, 2$  b.  $x = 2 \pm \sqrt{2}$   
 c. up:  $(-\infty, 2 - \sqrt{2}), (2 + \sqrt{2}, \infty)$   
 down:  $(2 - \sqrt{2}, 2 + \sqrt{2})$



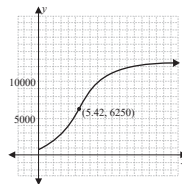
39. a.  $x = 0$  b. None  
 c. up:  $(-\infty, \infty)$



41. a. 20 units  
 b. \$51.50 each
43. 10,432 people per day
45. 209 bacteria per hour
47. 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

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

51. a. 2876 videos  
 b. 1107 videos per week  
 c. 39.5 weeks  
 d. during the 6<sup>th</sup> week



53. a.  $k = \ln 10 \approx 2.3$   
 b.  $k = \ln \pi \approx 1.145$

55.  $f'(x) = 2xe^{-x^2}$   
 $\left[ \frac{1}{x^2 + 2} - \ln(x^2 + 2) \right]$ ;  
 Abs. max:  $(0, 0.693)$   
 inf. pts:  $(-1.039, 0.382)$   
 and  $(1.039, 0.382)$

## 5.5 EXERCISES

1. a.  $p(t) = 8400e^{0.035t}$   
 b. 11,920 people  
 c. 12 years, or in the year 2012
3. \$21.33      5. 17.7 hours
7. 12.7 years      9. 8 years
11. 10.7 years      13. 8700 years
15. 11.8 lb/in.<sup>2</sup>      17. \$18,846
19. 0.777; 23.1 hours
21. a. 800 fish      b. 4303 fish  
 c. 5.9 years
23. 13.5 minutes      25. \$11,880.94

## 5.6 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.  $E = -\frac{pe^{-\frac{p}{10}}}{10\left(1 - e^{-\frac{p}{10}}\right)}$

- 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.

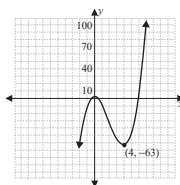
25. a.  $p = \$264.75$   
 b.  $D'(x) = -3xe^{-\frac{x^2}{200}}$   
 c.  $E = 4$     d.  $x = 10$

## Chapter 6: Integration with Applications

### 6.1 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  
 c.



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

### 6.2 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

**6.3 EXERCISES**

1. 12                      3. 21

5. 5.38                    7. 29

9. Left-endpoint est. = 2.25  
(underestimate); right-endpoint  
est. = 6.25 (overestimate);  
midpoint est. = 3.875  
(underestimate)11. Left-endpoint  
est. = right-endpoint est.  
=  $2 + 2\sqrt{3} \approx 5.464$   
(underestimate); midpoint  
est.  $\approx 6.519$  (overestimate)**6.4 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

**6.5 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.**6.6 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

**6.7 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.  $2x^2y'' - xy' - 2y$   
=  $2x^2(6) - x(6x + 5)$   
=  $4 - 15x$

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.  $D(x) = \frac{96}{x^{\frac{2}{3}}}$

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

## Chapter 7: Additional Integration Topics

### 7.1 EXERCISES

1.  $\frac{1}{4}e^{2x}(2x-1) + C$

3.  $4e^{0.5y}(y-2) + C$

5.  $t(\ln t - 1) + C$

7.  $\frac{1}{16}x^4(4\ln 5x - 1) + C$

9.  $\frac{2}{15}(x+2)^{\frac{3}{2}}(3x-4) + C$

11.  $-x(x+4)^{-1} + \ln|x+4| + C$

13.  $-\frac{5}{18}e^{-0.6t}(3t+5) + C$

15.  $\frac{2}{9}x^{\frac{3}{2}}(3\ln 7x - 2) + C$

17.  $\frac{1}{4} - \frac{5}{4}e^{-4} \approx 0.23$

19.  $\frac{9}{16} - \frac{13}{16}e^{-4} \approx 0.55$

21.  $\frac{2}{3} \approx 0.67$

23.  $u = 4x, dv = (3x+1)^5 dx;$   
 $\frac{5158}{7} \approx 736.86$

25.  $u = x+1, dv = (x+2)^{\frac{3}{2}} dx;$   
 $\frac{836}{35} \approx 23.89$

27.  $u = \ln x, dv = x^2 dx;$   
 $\frac{125}{3} \ln 5 - \frac{124}{9} \approx 53.28$

29.  $u = \ln(x+1), dv = dx;$   
 $7 \ln 7 - 6 \approx 7.62$

31.  $-\frac{5}{4}e^{-2t}(2t+1) + C$

33.  $\frac{2\sqrt{3}}{9}x^{\frac{3}{2}}(3\ln x - 2) + C$

35.  $\frac{3}{10}(2x^2 - 1)^{\frac{5}{2}} + C$

37.  $\frac{1}{3}(\ln x)^3 + C$

39.  $-\ln|1 - e^x| + C$

41.  $D(t) = 100te^{0.01t} - 10,000e^{0.01t}$   
 $+ 10,080$  million units

43.  $R(x) = 18.4x - 0.4x \ln x$  dollars

### 7.2 EXERCISES

1. \$15,319.26

3. \$63,498.35

5. \$17,872.00

7. \$1,876,681.25

9. \$26,808

11. \$91,814.99

13. \$34,737.82

15. \$32,411.16

17. \$609.83

19. \$22,848.88

21. \$850.08

23. \$45,734.16

25. \$115,577.27

27. Yes, both forms of the integral result in the same formula for the future value of an annuity,

$$\int_0^N Pe^{r(N-t)} dt = \int_0^N Pe^{rt} dt = \frac{P}{r}(e^{rN} - 1).$$

### 7.3 EXERCISES

1.  $\frac{1}{4} \ln|4x+3| + C$

3.  $-\frac{20}{3}e^{-0.15x} + C$

5.  $-\frac{1}{2(2x-5)} + C$

7.  $\frac{2(9x+8)}{135} \cdot (3x-4)^{\frac{3}{2}} + C$

9.  $\frac{x}{2}\sqrt{x^2+36}$

$+ 18 \ln|x + \sqrt{x^2+36}| + C$

11.  $\frac{1}{8} \ln \left| \frac{x-4}{x+4} \right| + C$

13.  $-\frac{1}{41} \ln \left| \frac{x+8}{5x-1} \right| + C$   
 $= \frac{1}{41} \ln \left| \frac{5x-1}{x+8} \right| + C$

15.  $\frac{7x^6}{6} \left( \ln x - \frac{1}{6} \right) + C$

17.  $\frac{x}{8} + \frac{1}{5.6} \ln|8e^{-0.7x} - 5| + C$

19.  $-2 \ln \left| \frac{x}{3x-1} \right| + C$   
 $= 2 \ln \left| \frac{3x-1}{x} \right| + C$

21.  $\frac{14}{9}(6x-5)^{\frac{3}{2}} + C$

23.  $-8 \ln \left| \frac{2x+5}{x} \right| + C = 8 \ln \left| \frac{x}{2x+5} \right| + C$

25.  $\frac{x^3 e^{1.5x}}{1.5} - \frac{3x^2 e^{1.5x}}{(1.5)^2}$   
 $+ \frac{6x e^{1.5x}}{(1.5)^3} - \frac{6e^{1.5x}}{(1.5)^4} + C$

27.  $\frac{1}{37} \left( \frac{2}{5} \ln|5x+2| + 7 \ln|x-7| + C \right)$

29.  $\ln|x + \sqrt{x^2 - 12}| + C$

7.4 EXERCISES

- 1. 0
- 5. 0
- 9. 0
- 13. Divergent
- 15.  $3e^{-20} \approx 0.0000000062$
- 17.  $3e^{-\frac{2}{3}} \approx 1.54$
- 21.  $\frac{1}{3}$
- 25. Divergent
- 29.  $\frac{1}{2}$
- 31.  $\frac{1}{2(\ln 2)^2} \approx 1.04$
- 33. 1
- 37. Area unbounded, integral divergent
- 39. d
- 3.  $+\infty$
- 7. 2
- 11.  $\frac{1}{2}$
- 19. Divergent
- 23. Divergent
- 27.  $\frac{1}{3}$
- 35. 2

7.5 EXERCISES

$$1. \int_0^4 \frac{3}{16} \sqrt{x} \, dx = \frac{3}{16} \left( \frac{2}{3} \right) x^{\frac{3}{2}} \Big|_0^4 = 1$$

$$3. \int_{-1}^2 \frac{4}{15} \left( \frac{1}{2}x + 1 \right) dx = \frac{4}{15} \left( \frac{x^2}{4} + x \right) \Big|_{-1}^2 = 1$$

$$5. \int_1^9 \frac{3}{68} (x - \sqrt{x}) dx = \frac{3}{68} \left( \frac{x^2}{2} - \frac{2}{3}x^{\frac{3}{2}} \right) \Big|_1^9 = 1$$

$$7. \int_1^{e^2} \frac{1}{2x} dx = \frac{1}{2} \ln|x| \Big|_1^{e^2} = 1$$

$$9. \int_{-2}^2 \frac{3}{32} (4 - x^2) dx = \frac{3}{32} \left( 4x - \frac{x^3}{3} \right) \Big|_{-2}^2 = 1$$

$$11. \int_0^{+\infty} 2e^{-2x} dx = 2 \lim_{b \rightarrow +\infty} \int_0^b e^{-2x} dx = 2 \lim_{b \rightarrow +\infty} \left( \frac{e^{-2x}}{-2} \right) \Big|_0^b = - \lim_{b \rightarrow +\infty} (e^{-2b} - 1) = -(-1) = 1$$

- 13. a.  $\frac{2}{9}$  b. 1
- 15. a.  $\frac{1}{2}$  b.  $\frac{7}{3}$
- 17. a.  $\frac{1}{4}$  b. 4

- 19. a.  $\frac{32}{15}$  b.  $\frac{8}{5}$
- 21.  $\frac{13}{27}$
- 23.  $e^{-4} \approx 0.018$
- 25.  $\frac{2}{5}$ ; 10 minutes
- 27.  $\frac{1}{64}$ ; 1.8 seconds
- 29.  $-e^{-0.3} + 1 \approx 0.259$

7.6 EXERCISES

- 1.  $\frac{8\pi}{3}$
- 5.  $\frac{\pi}{2} (e^4 - e^{-2}) \approx 27.23\pi$
- 7.  $\frac{\pi}{2} (11 - 4e^{-3} - e^{-6}) \approx 5.40\pi$
- 9.  $\frac{393\pi}{5}$
- 13.  $\frac{128\pi}{3}$
- 17.  $2\pi$
- 19.  $4\pi (\ln 5) \approx 6.44\pi$
- 21.  $\frac{\pi}{30}$
- 23.  $\frac{251\pi}{30}$
- 3.  $32\pi$
- 11.  $\frac{16\pi}{15}$
- 15.  $18\pi$

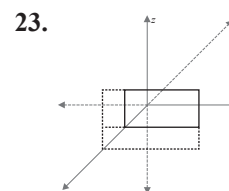
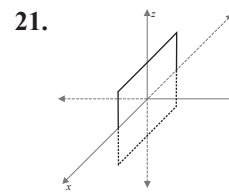
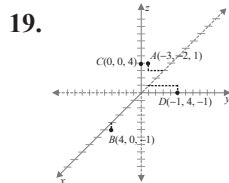
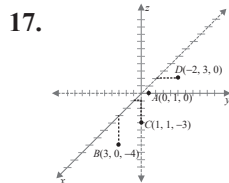
Chapter 8: Multivariable Calculus

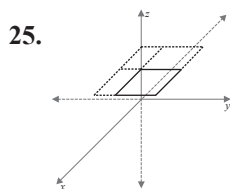
8.1 EXERCISES

- 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





25.

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

### 8.2 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.  $P_y(x, y) = 10,000x$

### 8.3 EXERCISES

- $f(3, -1) = -14$  is a local minimum.
- $(5, 1, -15)$  is a saddle point.
- $f\left(\frac{5}{2}, 4\right) = \frac{133}{4}$  is a local maximum.
- $(1, -2, -3)$  is a saddle point.
- $f(-2, -1) = -18$  is a local minimum.
- $f(2, 2) = -3$  is a local minimum.
- $f(1, -2) = 13$  is a local maximum.
- $f(1, 3) = 0$  is a local minimum;  $(-1, 3, 4)$  is a saddle point.
- $(2, 5, 7)$  is a saddle point;  $f(2, 1) = -25$  is a local minimum.
- $(2, 1, 8)$  is a saddle point;  $(-2, -1, -8)$  is a saddle point.
- $f(0, 0) = 0$  is a local minimum;  $(2, 2, 4)$  is a saddle point;  $(-2, 2, 4)$  is a saddle point.
- $f(1, 2) = 6$  is a local minimum.
- 30 of model X, 25 of model Y

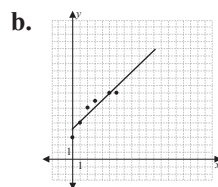
- 200 of the \$50 racks, 240 of the \$45 racks
- \$16 for the adult T-shirt, \$13 for the youth T-shirt
- 9 inches by 6 inches by 3 inches

### 8.4 EXERCISES

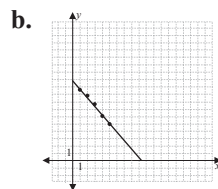
- $f(2, 2) = 8$
- $f(1, -1) = 7$
- $f(9, 6) = 612$
- $f(4, 4) = 128$
- $f(5, 2) = 30$
- $f(4, 5) = 112$
- $f(5, 2) = 69$
- $f(8, 15) \approx 175$
- $f(6, 3) = f(-6, -3) = 72$  is a maximum;  
 $f(6, -3) = f(-6, 3) = -72$  is a minimum
- $f(12, -6) = 864$  is a maximum;  
 $f(4, 2) = 96$  is a minimum
- 3 units in LA, 37 units in OKC
- approximately 3605 units
- 10 days in each area
- 69 feet by 36 feet with the interior lanes 36 feet long

### 8.5 EXERCISES

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



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



- $y = -0.12x + 8.19$
- $y = 14.7x + 221.9$
- $y = 1.1x + 4.02$
- a.  $y = 3.77x + 21.91$   
b. 37,000 units
- a.  $y = 11.17x + 4.07$   
b. \$82,260
- a.  $y = -0.663x + 76.04$   
b. 71.40 cents per pound
- a.  $y = 0.05x + 1.98$   
b. 2.28 million units

### 8.6 EXERCISES

- $\frac{3}{2}$
- $\frac{117}{2}$
- $5\ln 2 \approx 3.47$
- $\frac{320}{3}$
- $e^3 - e^2 - e + 1 \approx 10.9$
- $\frac{4}{3}$
- 56
- $\frac{1}{2}(e^{11} - e^8 - e^3 + 1) \approx 28,437.05$
- $\frac{288}{5}$
- $\frac{508}{21}$
- $\frac{26}{3}$
- $\frac{98}{3}$
- $\frac{1}{6}$
- $\frac{31}{60}$
- $\frac{e^6}{3} - e^2 + \frac{2}{3} \approx 127.75$
- $\frac{3}{20}$
- $\frac{5}{3}$
- 34
- $\frac{32}{3}$
- $\frac{1}{3}$

## Chapter 9: Trigonometric Functions

### 9.1 EXERCISES

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

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

5.  $\frac{1}{\sqrt{3}}$

7. 0

9. -2

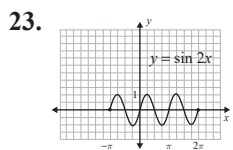
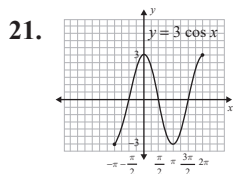
11.  $-\frac{1}{\sqrt{2}}$

13. 2.0778

15. -0.9143

17. -0.6737

19. 0.2482



29.  $\sin \theta = \frac{8}{17}, \csc \theta = \frac{17}{8},$

$\cos \theta = \frac{15}{17}, \sec \theta = \frac{17}{15},$

$\tan \theta = \frac{8}{15}, \cot \theta = \frac{15}{8}$

31. 2.236 miles

33. 15.307 ft

35. a.  $T_1 = 6$  b.  $T_2 = 9$

### 9.2 EXERCISES

1.  $-24 \sin(4x)$

3.  $-9 \sin^2 x \cos x$

5.  $\frac{1}{x} + 2 \sec^2(2x)$

7.  $-8x^2 \sin(8x) + 2x \cos(8x)$

9.  $\cos^2 x - \sin^2 x$

11.  $\frac{x \cos x - \sin x}{x^2}$

13.  $3e^{3x} \sec^2(e^{3x})$

15.  $-\frac{5 \sin(5x)}{2\sqrt{\cos(5x)}}$

17.  $4 \sec(4x) \tan(4x)$

19.  $2 \tan x \sec^2 x$

21. 0

23.  $-3e^{\cos x} \sin x$

25.  $\frac{\cos x}{\sin x} = \cot x$

27.  $\frac{1}{1 + \cos x}$

29.  $\frac{\partial f}{\partial x} = 4 + y \cos(xy)$

$\frac{\partial f}{\partial y} = x \cos(xy)$

31.  $\frac{\partial f}{\partial x} = ye^{xy} + y \cos x$

$\frac{\partial f}{\partial y} = xe^{xy} + \sin x$

33.  $\frac{\partial f}{\partial x} = -15x^3 \sin(3x + y) + 15x^2 \cos(3x + y)$

$\frac{\partial f}{\partial y} = -5x^3 \sin(3x + y)$

39.  $y = -\frac{\pi}{3}x + \frac{2\pi}{3} + \sqrt{3}$

41. a. \$9800 b. 0

c. The monthly revenue is not changing for September.

### 9.3 EXERCISES

1.  $\frac{1}{4} \sin(4x) + C$

3.  $\frac{1}{4} \tan(4x) + C$

5.  $-\frac{1}{7} \ln|\cos(7x+1)| + C$

7.  $-\frac{1}{2} \cos(x^2) + C$

9.  $\frac{3}{4}$  11. 2

13.  $\frac{1}{8}$  15.  $\sin(e^x) + C$

17.  $-e^{\cos x} + C$

19.  $-2 \ln|\cos \sqrt{x}| + C$

21.  $-\cos(\ln x) + C$

23.  $\ln(1.5) \approx 0.4055$

25.  $-\frac{1}{6}$

27.  $\ln|\sin x| + C$

29.  $\frac{1}{2}x - \frac{1}{4} \sin(2x) + C$

31.  $\frac{1}{2}x \sin(2x) + \frac{1}{4} \cos(2x) + C$

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

35. 6

37.  $\sqrt{2} - \frac{1}{2} \approx 0.9142$

39. 19.7392

41. 2772 people

### 9.4 EXERCISES

1.  $60^\circ$  3.  $-60^\circ$

5.  $\frac{3\pi}{4}$  7.  $\frac{\pi}{6}$

9. -0.63 11. 0.62

13. -0.72 15.  $\frac{-2x}{\sqrt{1-x^4}}$

17.  $\frac{1}{2\sqrt{x-x^2}}$  19.  $\frac{e^x}{1+e^{2x}}$

21.  $\frac{-2}{\sqrt{1-(2x+1)^2}}$

23.  $\frac{-3}{\sqrt{1-(1-3x)^2}}$

25.  $\frac{1}{2} \tan^{-1}(2x) + C$

27.  $\tan^{-1}(e^x) + C$

29.  $2 \sin^{-1}(\sqrt{x}) + C$

31.  $\frac{\pi}{12}$

33.  $\frac{\pi}{2}$

35.  $\frac{\pi^2}{4}$

37. a. 6.94 votes per percent of homes visited

b. The number of votes gained is increasing at a rate of 6.94 votes per percent of homes visited.

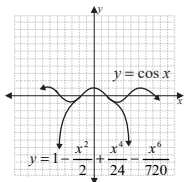
## Chapter 10: Sequences, Taylor Polynomials, and Power Series

### 10.1 EXERCISES

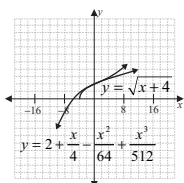
- $\left\{-1, \frac{1}{2}, -\frac{1}{3}, \frac{1}{4}, -\frac{1}{5}, \dots\right\}$
- $\{\sqrt{3}, \sqrt{5}, \sqrt{7}, \sqrt{9}, \sqrt{11}, \dots\}$
- $\{0, 1, 2, 3, 4, \dots\}$
- $f(n) = (-1)^{n+1}(2n+1)$
- $f(n) = 5n$
- $f(n) = n^2 + 1$
- 1
- $\frac{17}{18}$       17. 165
- 25      21. 3
- $\sqrt{2} + 2$       25.  $-\frac{2}{3}$
- Diverges      29. 3.63
- a. 1 foot    b.  $\frac{5}{3} \approx 1.67$  feet
- 14 milligrams
- \$450 billion
- a.  $\frac{43}{99}$     b.  $\frac{500}{99}$

### 10.2 EXERCISES

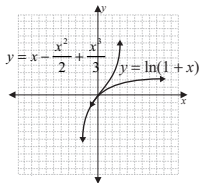
- $y = (e+1)x - 1$
- $\cos x \approx P_6(x) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!}$



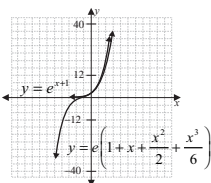
- $\sqrt{x+4} \approx P_3(x)$   
 $= 2 + \frac{x}{4} - \frac{x^2}{64} + \frac{x^3}{512}$



$$7. \ln(1+x) \approx P_3(x) = x - \frac{x^2}{2} + \frac{x^3}{3}$$



$$9. e^{x+1} \approx P_3(x) = e \left( 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} \right)$$



- $e^x \approx P_4(x)$   
 $= e + e(x-1) + \frac{e(x-1)^2}{2!}$   
 $+ \frac{e(x-1)^3}{3!} + \frac{e(x-1)^4}{4!}$
- $\cos x \approx P_6(x) = -1 + \frac{(x-\pi)^2}{2!}$   
 $- \frac{(x-\pi)^4}{4!} + \frac{(x-\pi)^6}{6!}$
- $\sqrt{x} \approx P_4(x) = 1 + \frac{1}{2}(x-1)$   
 $- \frac{1}{4} \frac{(x-1)^2}{2!} + \frac{3}{8} \frac{(x-1)^3}{3!}$   
 $- \frac{15}{16} \frac{(x-1)^4}{4!}$
- $\frac{1}{1-x} \approx P_4(x) = 2 + 4(x-0.5)$   
 $+ 8(x-0.5)^2 + 16(x-0.5)^3$   
 $+ 32(x-0.5)^4$
- 2.2114
- $\sqrt{2} \approx 1.4375$
- $\sqrt[4]{0.5} \approx 0.8447$
- $\sqrt[3]{27.5} \approx 3.0184$
- $\cos^2 x = 1 - \sin^2 x$   
 $\approx 1 - x^2 + \frac{x^4}{3} - \frac{2x^6}{45}$
- $f(x) \approx P_4(x)$   
 $= 3 - 2x + 4x^2 - 2x^3$

When  $k$  is greater than or equal to the degree of a polynomial function  $f(x)$ , the Taylor polynomial of degree  $k$  is the same as  $f(x)$ .

### 10.3 EXERCISES

- $y = \sum_{n=0}^{\infty} \frac{1}{n!} x^{n+2}$
- a.  $\sum_{n=0}^{\infty} (-1)^n t^n$   
b.  $\sum_{n=0}^{\infty} (-1)^n t^{2n}$   
c.  $\sum_{n=0}^{\infty} (-1)^n t^{n+1}$   
d.  $\sum_{n=0}^{\infty} (-1)^n t^{2n+1}$
- a.  $g'(x) = \frac{2x}{(1-x^2)^2}$ ,  
 $g''(x) = \frac{2(1+3x^2)}{(1-x^2)^3}$ ,  
 $g'''(x) = \frac{24x(1+x^2)}{(1-x^2)^4}$ ,  
 $g^{(4)}(x) = \frac{24(1+10x^2+5x^4)}{(1-x^2)^5}$
- a.  $P_4(x) = 1 + x^2 + x^4$   
b.  $g(x) = \frac{1}{1-x^2}$   
 $= 1 + x^2 + x^4 + \dots$
- a.  $\cosh t = 1 + \frac{t^2}{2!} + \frac{t^4}{4!}$   
b.  $\cosh t = 1 + \frac{t^2}{2!} + \frac{t^4}{4!} + \frac{t^6}{6!} + \dots$
- a.  $f'(x) = \frac{1}{(1-x)^2}$   
b.  $f'(x) = 1 + 2x + 3x^2 + 4x^3 + \dots$   
c.  $f'(x) = \frac{1}{(1-x)^2}$   
 $= \sum_{n=0}^{\infty} (n+1)x^n$

$$11. \lim_{t \rightarrow 0} \left( \frac{\sin t}{t} \right) \\ = \lim_{t \rightarrow 0} \left( 1 - \frac{t^2}{3!} + \frac{t^4}{5!} - \frac{t^6}{7!} + \dots \right) = 1$$

$$13. \text{ a. } f(x) = \frac{x^3}{1-x}$$

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

$$\text{ c. } f(x) = \frac{1}{1-x} - x^3$$

$$\text{ d. } f(x) = (1+x)^6$$

$$15. \cos\left(\frac{2\pi k}{7}\right) + i \sin\left(\frac{2\pi k}{7}\right)$$

for  $k = 0, 1, \dots, 6$

$$17. f(x) \approx P_4(x) = 1 + 2x \\ + x^2 + \frac{1}{3}x^3 + \frac{1}{12}x^4$$

$$19. f(x) \approx P_4(x) = 1 + x - \frac{1}{6}x^3$$

21. The Taylor series of an odd function contains only odd powers. The even powers all have a coefficient of 0.

$$23. \text{ a. } 0.6931471806$$

$$\text{ b. } \ln 2 \approx 0.6931$$

$$\text{ c. } 0.5 + \frac{(0.5)^2}{2} + \frac{(0.5)^3}{3} \\ + \frac{(0.5)^4}{4} + \frac{(0.5)^5}{5} + \dots$$

$$\text{ d. } \sum_{n=1}^{\infty} \frac{(0.5)^n}{n} = \ln 2 \approx 0.6931$$

$$25. \text{ a. } \arctan x = \sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} x^{2n+1}$$

$$\text{ b. } \pi = 4 \left( 1 - \frac{1}{3} + \frac{1}{5} - \dots \right)$$