Solutions for Calculus and Its Applications Brief Version 12th Edition by Bittinger

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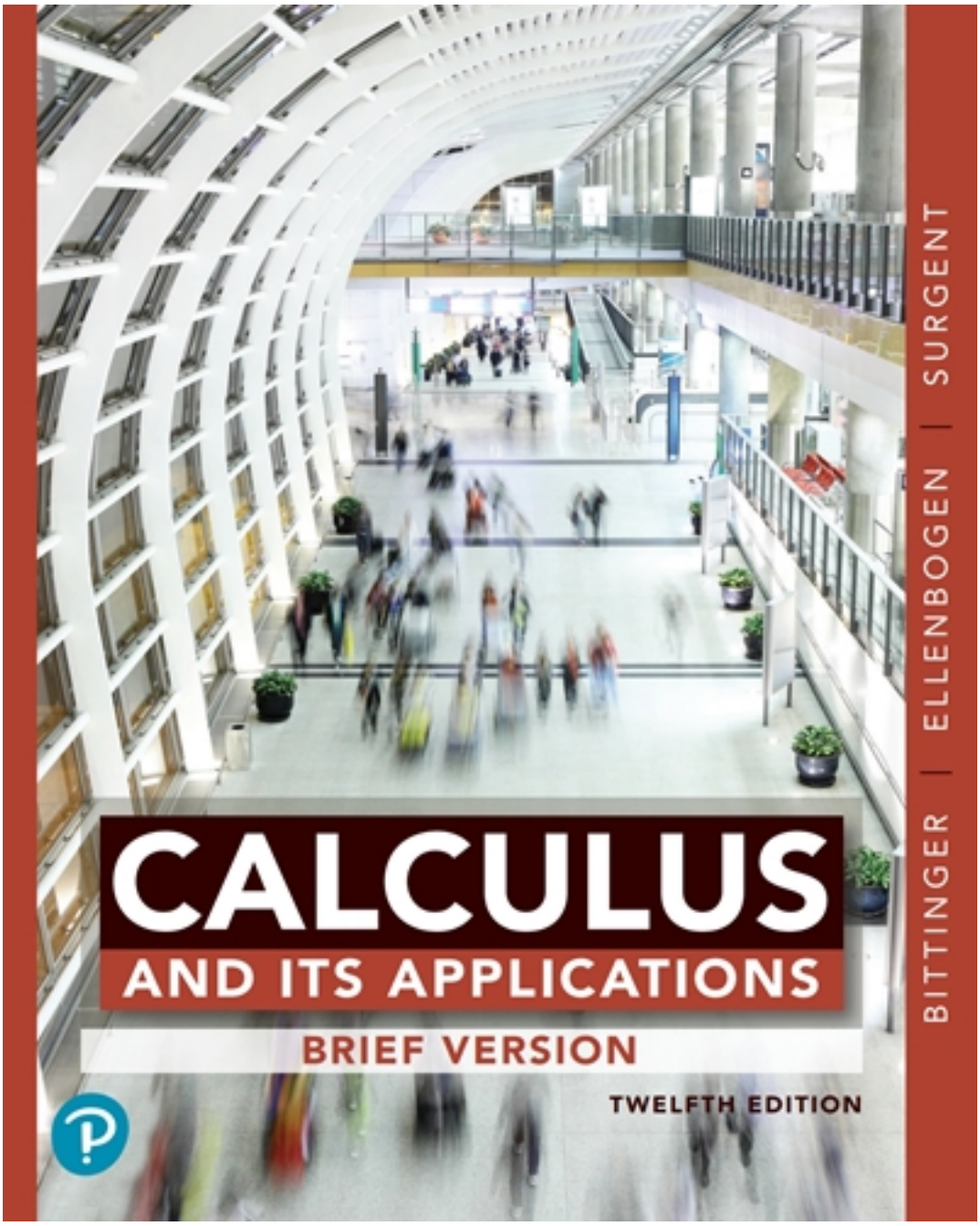
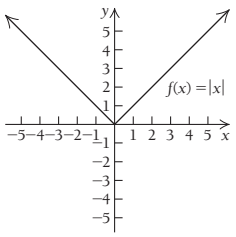


Solutions

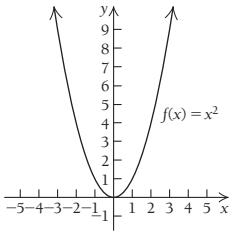
INSTRUCTOR ANSWERS: CHAPTER 1

Exercise Set 1.1, p. 112

1. $0.3, x \to 0.3^-$ **2.** $1.7, x \to 1.7^+$ **3.** $-3, x \to -3^-$
4. $-4.9, x \to -4.9^+$ **5.** $\frac{2}{3}, x \to \left(\frac{2}{3}\right)^-$ **6.** $\frac{4}{3}, x \to \left(\frac{4}{3}\right)^-$
7. $0.3, x \to 0.3^-$ **8.** $1.2, x \to 1.2^-$ **9.** $1, x \to 1^+$
10. $0, x \to 0^-$ **11.** -2 **12.** 7 **13.** $\lim_{x \to 2^+}$
14. $\lim_{x \to 3^-}$ **15.** $\lim_{x \to 5}$ **16.** $\lim_{x \to \frac{1}{2}}$ **17.** "the limit, as x approaches 4, of $f(x)$" or "the limit of $f(x)$ as x approaches 4"
18. "the limit, as x approaches 1, of $g(x)$" or "the limit of $g(x)$ as x approaches 1" **19.** "the limit, as x approaches 5 from the left, of $F(x)$" or "the limit of $F(x)$ as x approaches 5 from the left"
20. "the limit, as x approaches 4 from the right, of $G(x)$" or "the limit of $G(x)$ as x approaches 4 from the right" **21. (a)** -3; **(b)** -3; **(c)** -3 **22. (a)** 1; **(b)** 2; **(c)** does not exist
23. (a) -1; **(b)** -1; **(c)** -1 **24. (a)** 4; **(b)** 2; **(c)** does not exist **25.** 5 **26.** 4 **27.** Does not exist **28.** 0 **29.** 2
30. 0 **31.** 2 **32.** 4 **33.** 1 **34.** 3 **35.** 4 **36.** -1
37. 0 **38.** Does not exist **39.** 0 **40.** 0 **41.** 0 **42.** 1
43. 1 **44.** 1 **45.** 4 **46.** 2 **47.** 1 **48.** Does not exist
49. 1 **50.** 1 **51.** -1 **52.** 1 **53.** 2 **54.** Does not exist
55. Does not exist **56.** 0 **57.** 0 **58.** 3 **59.** 2 **60.** 1

61.


0, 2

62.


1, 0

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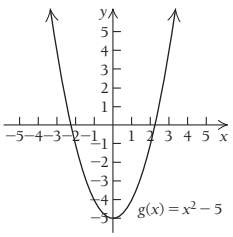

$-5, -4$

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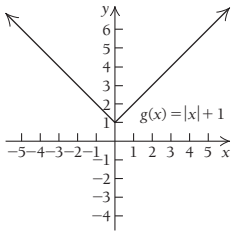

4, 1

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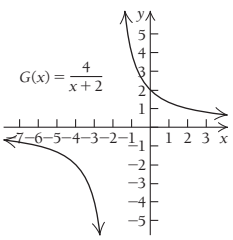

4, does not exist

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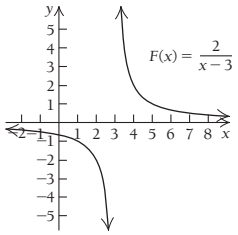

does not exist, 2

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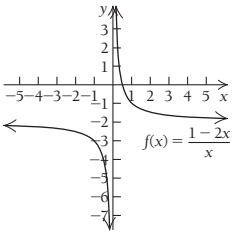

-2, does not exist

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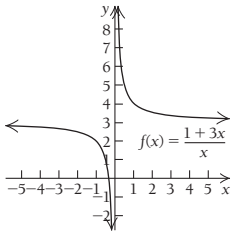

3, does not exist

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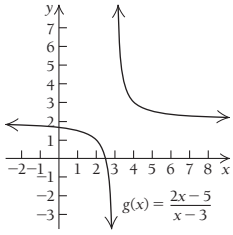

2, does not exist

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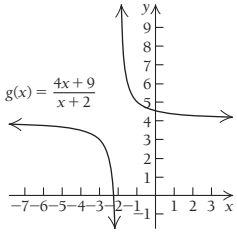

4, does not exist

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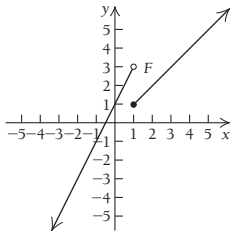

3, 1, does not exist

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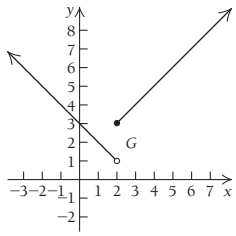

1, 3, does not exist

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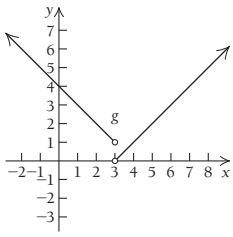
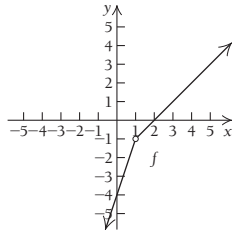
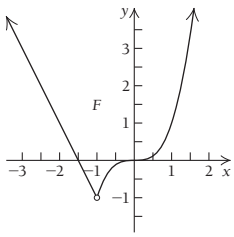


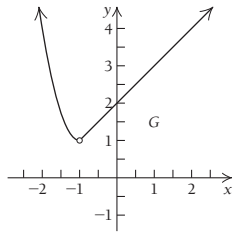
1, 0, does not exist

74.


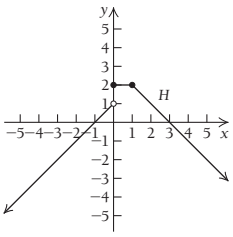
$-1, -1, -1$

75.


-1

76.


1

77.


does not exist, 2

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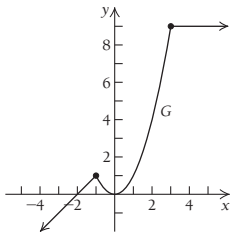


1, 9

79. $3.50, $3.50, $3.50 **80.** $3.00, $3.50, does not exist
81. $4.00, $4.50, does not exist **82.** $1.00, $1.21, does not exist
83. $1.21, $1.42, does not exist **84.** $1.42, $1.42, $1.42
85. Does not exist **86.** $1.63 **87.** 10%, 12%, does not exist
88. 12%, 12%, 12% **89.** 22%, does not exist
90. 10%, 10%, 10% **91.** 12%, 22%, does not exist
92. 22%, does not exist **93.** 3 **94.** -3 **95.** -1
96. (a) 0; **(b)** 2; **(c)** answers may vary.
97. (a) 4; **(b)** 4, **(c)** 4; **(d)** 4; **(e)** 4; **(f)** no; **(g)** yes
98. Does not exist, 2 **99.** 0, 0 **100.** Does not exist, $\frac{1}{6}$

Exercise Set 1.2, p. 124

1. True **2.** False **3.** True **4.** True **5.** True **6.** False **7.** False **8.** True **9.** 5 **10.** 3 **11.** -3 **12.** 7 **13.** 4 **14.** 4 **15.** 15 **16.** 10 **17.** 1 **18.** -4 **19.** 10 **20.** 6 **21.** $\frac{7}{2}$ **22.** $\frac{3}{2}$ **23.** $-\frac{13}{6}$ **24.** $\frac{13}{4}$ **25.** 3 **26.** -12 **27.** -6 **28.** $\frac{1}{10}$ **29.** Does not exist **30.** Does not exist **31.** $\frac{5}{4}$ **32.** $\frac{7}{3}$ **33.** $\frac{1}{6}$ **34.** 3 **35.** $\frac{1}{3}$ **36.** $\frac{1}{2}$ **37.** 0 **38.** 0 **39.** Does not exist **40.** Does not exist **41.** 3 **42.** $\sqrt{7}$ **43.** Does not exist **44.** Does not exist **45.** 0 **46.** 0 **47.** Not continuous **48.** Not continuous **49.** Continuous **50.** Not continuous **51.** Not continuous **52.** **(a)** $-2, -2, -2$; **(b)** -2; **(c)** yes, the limit exists and equals the function value; **(d)** does not exist; **(e)** -3; **(f)** no, the limit does not exist. **53.** **(a)** -1, 2, does not exist; **(b)** -1; **(c)** no, the limit does not exist; **(d)** 3; **(e)** 3; **(f)** yes, the limit exists and equals the function value. **54.** **(a)** 2; **(b)** 2; **(c)** yes, the limit exists and equals the function value; **(d)** 0; **(e)** 0; **(f)** yes, the limit exists and equals the function value. **55.** **(a)** 2; **(b)** does not exist; **(c)** no, the function value does not exist; **(d)** -2; **(e)** -2; **(f)** yes, the limit exists and equals the function value. **56.** **(a)** 0.25; **(b)** 0.25; **(c)** yes, the limit exists and equals the function value; **(d)** does not exist; **(e)** does not exist; **(f)** no, neither the limit nor $t(-2)$ exists. **57.** **(a)** 3; **(b)** 1; **(c)** does not exist; **(d)** 1; **(e)** no, the limit does not exist; **(f)** yes, the limit exists and equals the function value; **(g)** yes, the limit exists and equals the function value. **58.** **(a)** 1; **(b)** -1; **(c)** does not exist; **(d)** 1; **(e)** no, the limit does not exist; **(f)** yes, the limit exists and equals the function value. **59.** Yes, the limit exists and equals the function value at 4. **60.** Yes, the limit exists and equals the function value at 5. **61.** No, the limit does not exist and G is not defined at 0. **62.** No, F is not defined at -1. **63.** Yes, the limit exists and equals the function value at 4. **64.** Yes, the limit exists and equals the function value at 3. **65.** No, the limit does not exist at 3. **66.** No, the limit does not exist and G is not defined at 4. **67.** No, g is not defined at 4. **68.** Yes, the limit exists and equals the function value at 3. **69.** No, the limit value does not equal the function value at 2. **70.** No, the limit value does not equal the function value at 1. **71.** Yes, the limit exists and equals the function value at 4. **72.** Yes, the limit exists and equals the function value at 5. **73.** No, the limit does not exist and the function is not defined at 5. **74.** Yes, the limit exists and equals the function value at 3. **75.** No, the limit does not exist and the function is not defined at 2. **76.** Yes, the limit exists and equals the function value at 4. **77.** Yes, because $\lim_{x\to a} g(x) = g(a)$ for all a such that $-4 < a < 4$ **78.** Yes, because $\lim_{x\to a} F(x) = F(a)$ for all a such that $-5 < a < 5$ **79.** Yes, because $\lim_{x\to a} g(x) = g(a)$ for all a such that $1 < a < \infty$, and $\lim_{x\to 1^+} g(x) = g(1)$ **80.** Yes, because $\lim_{x\to a} h(x) = h(a)$ for all a such that $-3 < a < \infty$, and $\lim_{x\to -3^+} h(x) = h(-3)$ **81.** Yes, because $\lim_{x\to a} F(x) = F(a)$ for all a such that $-5 < a < 5$, and $\lim_{x\to -5^+} F(x) = F(-5)$ and $\lim_{x\to 5^-} F(x) = F(5)$ **82.** Yes, because $\lim_{x\to a} G(x) = G(a)$ for all a such that $-3 < a < 3$, and $\lim_{x\to -3^+} G(x) = G(-3)$ and $\lim_{x\to 3^-} G(x) = G(3)$ **83.** 30, 25, does not exist **84.** 8, 6, does not exist **85.** 120, 120, 120 **86.** Yes **87.** Yes **88.** Yes **89.** Yes **90.** No **91.** No **92.** Yes **93.** Yes **94.** 5 **95.** 2 **96.** **(a)** Does not exist; **(b)** -3 **97.** $a = \frac{19}{4}$, $b = -3$ **98.** $c = 9$ **99.** $\frac{1}{2}$ **100.** 6 **101.** $\frac{1}{2}$ **102.** $-\frac{1}{2\sqrt{3}}$ **103.** $\frac{1}{\sqrt{7}}$ **104.** $\frac{3}{4}$ **105.** 0 **106.** $\frac{1}{4}$

Exercise Set 1.3, p. 133

1. The temperature rose 3 degrees/hr. **2.** Jennifer hiked 3 mi/hr. **3.** Marcus delivered 7 packages/hr. **4.** The population of Felton grew by 100 people/yr. **5.** Tanya scored 25 points/game. **6.** Chris grew 7.5 cm/yr. **7.** Burnham Industries had 5,000,000 dollars/month in revenue. **8.** Juan spent 2.25 dollars/gallon on gasoline. **9.** Unemployment changed by -0.333 percentage point/month. **10.** Shannon spent 3.1 dollars/day on electricity for April. **11.** 3 **12.** 5 **13.** 2 **14.** 6 **15.** $-\frac{1}{32}$ **16.** $-\frac{3}{5}$ **17.** 8 **18.** 8 **19.** 4.25 **20.** 1.6 **21.** **(a)** $10x + 5h$; **(b)** 60, 55, 50.5, 50.05 **22.** **(a)** $8x + 4h$; **(b)** 48, 44, 40.4, 40.04 **23.** **(a)** $-10x - 5h$; **(b)** $-60, -55, -50.5, -50.05$ **24.** **(a)** $-8x - 4h$; **(b)** $-48, -44, -40.4, -40.04$ **25.** **(a)** $2x + h - 1$; **(b)** 11, 10, 9.1, 9.01 **26.** **(a)** $2x + h + 1$; **(b)** 13, 12, 11.1, 11.01 **27.** **(a)** $-\frac{9}{x(x+h)}$; **(b)** $-\frac{9}{35}, -\frac{3}{10}, -\frac{6}{17}, -\frac{60}{167}$ **28.** **(a)** $-\frac{2}{x(x+h)}$; **(b)** $-\frac{2}{35}, -\frac{1}{15}, -\frac{4}{51}, -\frac{40}{501}$ **29.** **(a)** 2; **(b)** 2, 2, 2, 2 **30.** **(a)** -2; **(b)** $-2, -2, -2, -2$ **31.** **(a)** $36x^2 + 36xh + 12h^2$; **(b)** 1308, 1092, 918.12, 901.8012 **32.** **(a)** $-3x^2 - 3xh - h^2$; **(b)** $-109, -91, -76.51, -75.1501$ **33.** **(a)** $2x + h - 4$; **(b)** 8, 7, 6.1, 6.01 **34.** **(a)** $2x + h - 3$; **(b)** 9, 8, 7.1, 7.01 **35.** **(a)** $2x + h - 3$; **(b)** 9, 8, 7.1, 7.01 **36.** **(a)** $2x + h + 4$; **(b)** 16, 15, 14.1, 14.01 **37.** 0.36 percentage point/yr, -0.3 percentage point/yr, 0.09 percentage point/yr **38.** 1.7 percentage point/yr, -0.2 percentage point/yr, 0.66 percentage point/yr **39.** 0.66 percentage point/yr, -0.15 percentage point/yr, 0.21 percentage point/yr **40.** -0.31 percentage point/yr, 0.1 percentage point/yr, -0.08 percentage point/yr **41.** 0.1 percentage point/yr, -0.04 percentage point/yr, 0.03 percentage point/yr **42.** -0.7 percentage point/yr, 0.46 percentage point/yr, -0.05 percentage point/yr **43.** 2.1 percentage points/yr, -4.3 percentage points/yr, -1.5 percentage points/yr **44.** 1 percentage point/yr, -0.43 percentage point/yr, 0.2 percentage point/yr **45.** $-\$450$/yr, \$1266.67/yr, \$580/yr **46.** \$1.467 billion/yr, \$0.4 billion/yr, \$0.93 billion/yr **47.** **(a)** 70, 39, 29, 23; **(b)** answers may vary. **48.** **(a)** 300, 180, 120, 100; **(b)** answers may vary. **49.** **(a)** \$26.62; **(b)** \$31.16; **(c)** \$4.54; **(d)** 0.7567, which means that prices increased by an average of about \$0.76 per year **50.** **(a)** \$2391.24; **(b)** \$2693.71; **(c)** \$302.47; **(d)** \$151.24, which means the amount grew on average \$151.24 per year for 2 yr **51.** The average cost of production of between 300 and 305 holders is \$19.75 per unit. **52.** The average revenue from sales of between 300 and 305 holders is \$149.40 per unit. **53.** 17.62; the average rate of change in Amazon's revenue between 2014 and 2017 was \$17.62 billion per year. **54.** 41.35; the average rate of change in Panera Bread Co.'s income between 2014 and 2017 was \$41.35 million per year. **55.** **(a)** 1.49 hectares/g; **(b)** home range increases by 1.0902 hectares per gram as the animal's weight grows from 200 g to 300 g. **56.** **(a)** 50.33; the population grew by about 50 condors per year between 2010 and 2017. **(b)** 42.064; the population increased by about 42 condors per year between 2007 and 2015. **57.** **(a)** 1.25, 1.25, 0.625, 0, 0; **(b)** answers may vary. **58.** **(a)** 29.4 mi/gal; **(b)** 0.034 gal/mi **59.** **(a)** 256 ft; **(b)** 128 ft/sec **60.** **(a)** 184.05 mi, or the distance traveled from $t = 2$ hr to $t = 5$ hr; **(b)** 61.35 mi/hr **61.** **(a)** 125 thousand people/yr; **(b)** answers may vary; **(c)** **A:** 290 thousand people/year, -40 thousand people/yr, -50 thousand people/yr, 300 thousand people/yr;

B: 125 thousand people/yr, 125 thousand people/yr, 125 thousand people/yr, 125 thousand people/yr **(d)** answers may vary.

62. -116; Payton County lost an average of 116 people per year between the 5th and 8th years. **63.** 825.46; Harbor University's undergraduate population was increasing at the rate of 825.46 students per year between the 2nd and 6th years.

64. m **65.** $2ax + b + ah$ **66.** $3ax^2 + 3axh + ah^2 + 2bx + bh$

67. $4x^3 + 6x^2h + 4xh^2 + h^3$

68. $5x^4 + 10x^3h + 10x^2h^2 + 5xh^3 + h^4$

69. $5ax^4 + 10ax^3h + 10ax^2h^2 + 5axh^3 + ah^4 + 4bx^3 + 6bx^2h + 4bxh^2 + bh^3$ **70.** $\dfrac{-2x - h}{(x + h)^2x^2}$

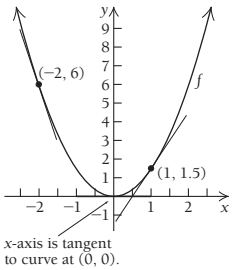
71. $\dfrac{1}{(1 - x - h)(1 - x)}$ **72.** **(a)** Multiplying by 1; **(b)** performing multiplication in the numerator; **(c)** combining like terms and simplifying; **(d)** when h is not 0, then $h/h = 1$.

73. $\dfrac{2}{\sqrt{2(x + h) + 1} + \sqrt{2x + 1}}$

74. $\dfrac{-1}{\sqrt{x}\sqrt{x + h}(\sqrt{x} + \sqrt{x + h})}$

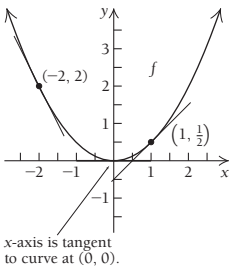
Exercise Set 1.4, p. 144

1. **(a)** and **(b)**



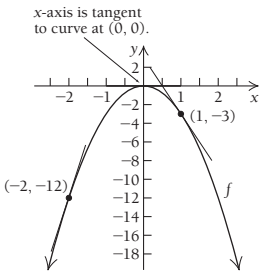
(c) $f'(x) = 3x$; **(d)** $-6, 0, 3$

2. **(a)** and **(b)**



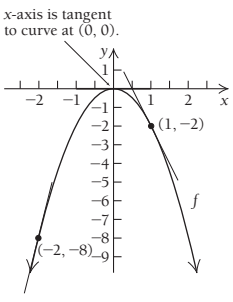
(c) $f'(x) = x$; **(d)** $-2, 0, 1$

3. **(a)** and **(b)**



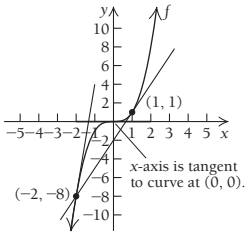
(c) $f'(x) = -6x$; **(d)** $12, 0, -6$

4. **(a)** and **(b)**



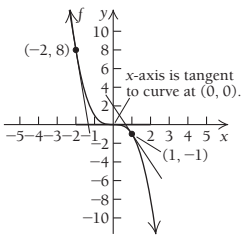
(c) $f'(x) = -4x$; **(d)** $8, 0, -4$

5. **(a)** and **(b)**



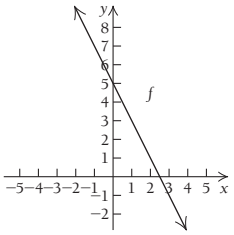
(c) $f'(x) = 3x^2$; **(d)** $12, 0, 3$

6. **(a)** and **(b)**



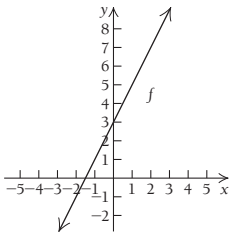
(c) $f'(x) = -3x^2$; **(d)** $-12, 0, -3$

7. **(a)** and **(b)**



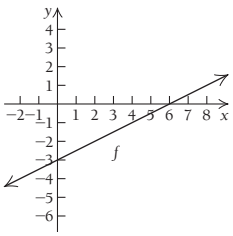
(c) $f'(x) = -2$; **(d)** $-2, -2, -2$

8. **(a)** and **(b)**



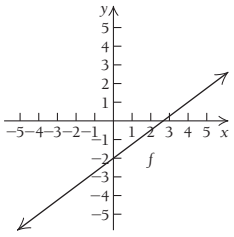
(c) $f'(x) = 2$; **(d)** $2, 2, 2$

9. **(a)** and **(b)**



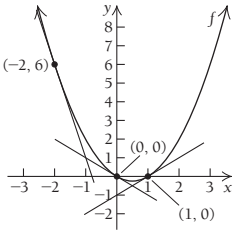
(c) $f'(x) = \frac{1}{2}$; **(d)** $\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$

10. **(a)** and **(b)**

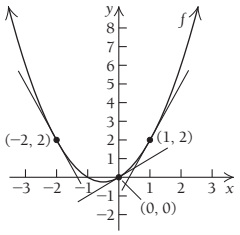


(c) $f'(x) = \frac{3}{4}$; **(d)** $\frac{3}{4}, \frac{3}{4}, \frac{3}{4}$

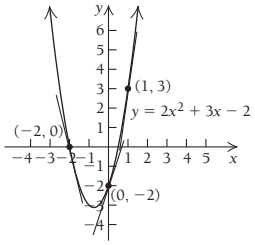
11. **(a)** and **(b)**



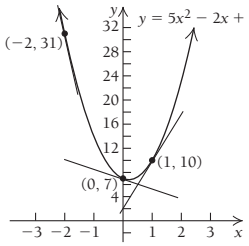
(c) $f'(x) = 2x - 1$; **(d)** $-5, -1, 1$

12. **(a)** and **(b)** 

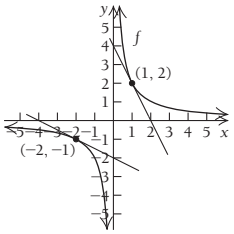
(c) $f'(x) = 2x + 1$; **(d)** $-3, 1, 3$

13. **(a)** and **(b)** 

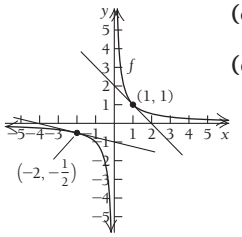
(c) $f'(x) = 4x + 3$; **(d)** $-5, 3, 7$

14. **(a)** and **(b)** 

(c) $f'(x) = 10x - 2$; **(d)** $-22, -2, 8$

15. **(a)** and **(b)** 

(c) $f'(x) = -\dfrac{2}{x^2}$; **(d)** $-\frac{1}{2}$, not defined, -2

16. **(a)** and **(b)** 

(c) $f'(x) = -\dfrac{1}{x^2}$; **(d)** $-\frac{1}{4}$, not defined, -1

17. **(a)** $y = 12x + 16$; **(b)** $y = 0$; **(c)** $y = 48x - 128$
18. **(a)** $y = 6x - 9$; **(b)** $y = -2x - 1$; **(c)** $y = 20x - 100$
19. **(a)** $y = -2x + 4$; **(b)** $y = -2x - 4$; **(c)** $y = -0.0002x + 0.04$
20. **(a)** $y = x + 2$; **(b)** $y = \dfrac{1}{4}x - 1$; **(c)** $y = \dfrac{1}{25}x + \dfrac{2}{5}$
21. **(a)** $y = -6x - 4$; **(b)** $y = -1$; **(c)** $y = 6x - 16$
22. **(a)** $y = 2x + 5$; **(b)** $y = 4$; **(c)** $y = -10x + 29$
23. $f'(x) = m$ **24.** $f'(x) = 2ax + b$ **25.** x_1, x_3, x_4, x_5, x_7
26. $x_0, x_2, x_4, x_5, x_6, x_7$ **27.** $x_0, x_3, x_4, x_6, x_{12}$ **28.** x_2, x_4, x_5, x_7, x_8
29. x_1, x_2, x_3, x_4 **30.** $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_9, x_{10}$
31–38. Left to the student **39.** False **40.** True **41.** False
42. False **43.** Answers may vary. **44.** Answers may vary.
45. $f'(x) = \dfrac{1}{(1-x)^2}$ **46.** $f'(x) = 5x^4$ **47.** $f'(x) = -\dfrac{2}{x^3}$
48. $f'(x) = \dfrac{1}{2\sqrt{x}}$ **49.** $f'(x) = \dfrac{1}{\sqrt{2x+1}}$ **50.** $f'(x) = -\dfrac{1}{2x\sqrt{x}}$
51. $f'(x) = 2ax + b$ **52.** Answers may vary. **53.** **(a)** $x = -3$; **(b)** answers may vary; **(c)** 1 **54.** **(a)** $x = 0$; **(b)** answers may vary; **(c)** $\frac{1}{2}$ (description of method left to the student)
55. **(a)** $x = 3$; **(b)** answers may vary; **(c)** $-1, -1, 1, 1$
56. **(a)** $x = -5$; **(b)** answers may vary; **(c)** $-2, -2, 2, 2$
57. Answers may vary. **58.** **(a)** Limit is 5 and $F(2) = 5$, so F is continuous at $x = 2$. **(b)** No, there is a corner at $x = 2$.
59. **(a)** Limit is 1 and $G(1) = 1$, so G is continuous at $x = 1$. **(b)** Yes, the graph is a smooth nonvertical curve at $x = 1$.
60. $m = 11, b = -18$ **61.** $\frac{3}{2}$ **62.** $\dfrac{5}{\sqrt{3}}$ **63.** The trucker's average speed was $290/4 = 72.5$, and his distance function is differentiable for the entire 4-hr drive, so he must have driven 72.5 miles per hour at least once in that 4-hr period. **64.** Because g is not differentiable everywhere in the interval

Exercise Set 1.5, p. 154

1. The derivative of u with respect to v is $f'(v)$; the derivative of u with respect to v is u'; the derivative of u with respect to v is $\dfrac{du}{dv}$, the derivative of u with respect to v is $\dfrac{d}{dv}f(v)$. **2.** The derivative of s with respect to t is $g'(t)$; the derivative of s with respect to t is s'; the derivative of s with respect to t is $\dfrac{ds}{dt}$; the derivative of s with respect to t is $\dfrac{d}{dt}g(t)$. **3.** The derivative of p with respect to q is $R'(q)$; the derivative of p with respect to q is p'; the derivative of p with respect to q is $\dfrac{dp}{dq}$; the derivative of p with respect to q is $\dfrac{d}{dq}R(q)$. **4.** The derivative of m with respect to n is $G'(n)$; the derivative of m with respect to n is m'; the derivative of m with respect to n is $\dfrac{dm}{dn}$; the derivative of m with respect to n is $\dfrac{d}{dn}G(n)$. **5.** The derivative of h with respect to k is $m'(k)$; the derivative of h with respect to k is h'; the derivative of h with respect to k is $\dfrac{dh}{dk}$; the derivative of h with respect to k is $\dfrac{d}{dk}m(k)$. **6.** The derivative of C with respect to z is $T'(z)$; the derivative of C with respect to z is C'; the derivative of C with respect to z is $\dfrac{dC}{dz}$; the derivative of C with respect to z is $\dfrac{d}{dz}T(z)$.
7. $7x^6$ **8.** $8x^7$ **9.** -3 **10.** -0.5 **11.** 0 **12.** 0
13. $30x^{14}$ **14.** $30x^9$ **15.** $-6x^{-7}$ **16.** $-8x^{-9}$ **17.** $-8x^{-3}$
18. $-15x^{-6}$ **19.** $3x^2 + 6x$ **20.** $4x^3 - 7$ **21.** $\dfrac{4}{\sqrt{x}}$
22. $\dfrac{2}{\sqrt{x}}$ **23.** $0.9x^{-0.1}$ **24.** $1.7x^{0.7}$ **25.** $\dfrac{2}{5}x^{-1/5}$
26. $-1.6x^{-2/3}$ **27.** $-\dfrac{21}{x^4}$ **28.** $-\dfrac{24}{x^5}$ **29.** $\dfrac{1}{4\sqrt[4]{x^3}} + \dfrac{3}{x^2}$
30. $\dfrac{1}{3\sqrt[3]{x^2}} - \dfrac{2}{x\sqrt{x}}$ **31.** $-\dfrac{10}{3}\sqrt[3]{x^2}$ **32.** $-\dfrac{3}{4\sqrt[4]{x}}$ **33.** $\dfrac{5}{11}$
34. $\dfrac{2}{3}$ **35.** $-\dfrac{12}{5x^7}$ **36.** $-\dfrac{12}{7x^4}$ **37.** $-\dfrac{4}{x^2} - \dfrac{3}{5}x^{-2/5}$
38. $-\dfrac{5}{x^2} - \dfrac{2}{3}x^{-1/3}$ **39.** 7 **40.** 4 **41.** $\dfrac{1}{2}\sqrt{x}$
42. $\dfrac{1}{3}\sqrt[3]{x}$ **43.** $-0.02x + 0.4$ **44.** $-0.02x - 0.5$
45. $-\dfrac{3}{4}x^{-7/4} - 2x^{-1/3} + \dfrac{5}{4}x^{1/4} - \dfrac{8}{x^5}$
46. $-2x^{-5/3} + \dfrac{3}{4}x^{-1/4} + \dfrac{6}{5}x^{1/5} - \dfrac{24}{x^4}$ **47.** $\dfrac{1}{7} - \dfrac{7}{x^2}$

48. $-\frac{2}{x^2}-\frac{1}{2}$ **49.** $\frac{1}{4}$ **50.** 24 **51.** -5 **52.** 1 **53.** $\frac{1}{12}$

54. 14 **55.** $-\frac{3}{640}$ **56.** $\frac{4}{3}$ **57. (a)** $y=\frac{3}{2}x-\frac{3}{2}$;

(b) $y=\frac{31}{4}x-17$; **(c)** $y=\frac{107}{6}x-\frac{165}{2}$

58. (a) $y=10x-15$; **(b)** $y=x+3$; **(c)** $y=-2x+1$

59. (a) $y=-\frac{2}{3}x+\frac{1}{3}$; **(b)** $y=\frac{2}{3}x+\frac{1}{3}$; **(c)** $y=\frac{1}{3}x+\frac{4}{3}$

60. (a) $y=-2x+3$; **(b)** $y=-\frac{2}{27}x+\frac{1}{3}$; **(c)** $y=\frac{1}{4}x+\frac{3}{4}$

61. $(0,4)$ **62.** $(0,-3)$ **63.** $(0,-2)$ **64.** $(0,1)$

65. $(0.3, 7.55)$ **66.** $\left(\frac{5}{6},\frac{23}{12}\right)$ **67.** $(20,54)$ **68.** $(-25,76.25)$

69. None **70.** None **71.** All points (the graph is a horizontal line) **72.** All points (the graph is a horizontal line)

73. $\left(1,-55\frac{1}{3}\right),\left(11,111\frac{1}{3}\right)$ **74.** $\left(\frac{5}{3},5\frac{13}{27}\right),(-1,-4)$

75. $(-\sqrt{2},1+4\sqrt{2}),(\sqrt{2},1-4\sqrt{2})$

76. $(-\sqrt{3},2+2\sqrt{3}),(\sqrt{3},2-2\sqrt{3})$ **77.** $(3,0)$

78. $(0,-2),\left(-1,-\frac{11}{6}\right)$ **79.** $(2.5, 8.75)$ **80.** $(9.5, 99.75)$

81. $(50, 75)$ **82.** $(60, 150)$

83. $\left(1+\sqrt{6},-\frac{11}{3}-3\sqrt{6}\right),\left(1-\sqrt{6},-\frac{11}{3}+3\sqrt{6}\right)$

84. $\left(-2+\sqrt{3},\frac{4}{3}-\sqrt{3}\right),\left(-2-\sqrt{3},\frac{4}{3}+\sqrt{3}\right)$

85. $\left(-\frac{1}{8},-\frac{11}{24}\right),\left(\frac{1}{8},\frac{11}{24}\right)$ **86.** $\left(1,\frac{3}{2}\right)$

87. (a) $w'(t)=1.82-0.1192t+0.002274t^2$; **(b)** 21.148 lb; **(c)** 0.855 pound per month **88. (a)** $T'(t)=-0.2t+1.2$; **(b)** 100.2 degrees **(c)** 0.9 degree per day

89. (a) $R'(v)=-\frac{6000}{v^2}$; **(b)** 75 beats per minute; **(c)** -0.9375 beat per minute **90. (a)** $S'(r)=-\frac{4}{r^5}$;

(b) 0.4823 unit of resistance;
(c) -12.2 units of resistance per millimeter

91. (a) $\frac{dP}{dt}=4000t$; **(b)** 300,000 people **(c)** 40,000 people per year **(d)** answers will vary. **92. (a)** $A'(t)=0.08$; **(b)** answers will vary. **93. (a)** $\frac{dv}{dh}=\frac{0.61}{\sqrt{h}}$; **(b)** 244 mi; **(c)** 0.00305 mile per foot gained; **(d)** answers will vary. **94. (a)** $\frac{ds}{dd}=\frac{1.55}{\sqrt{d}}$;

(b) 9.8 meters per second; **(c)** 0.49 meter per second per meter

95. (a) About \$1490; **(b)** $\frac{dp}{dt}=1.716t-18.864$;

(c) about \$72.08 per year **96.** $(2,\infty)$ **97.** $(-\infty,-1)\cup(3,\infty)$

98. $(0,-4),\left(\sqrt{\frac{2}{3}},-\frac{40}{9}\right),\left(-\sqrt{\frac{2}{3}},-\frac{40}{9}\right)$

99. $(0,-2),\left(\frac{1}{\sqrt{3}},-\frac{55}{27}\right),\left(-\frac{1}{\sqrt{3}},-\frac{55}{27}\right)$

100. $f'(x)=5x^4+3x^2$ is always nonnegative for all x.
101. $g'(x)=-2-3x^2$ is always negative for all x.

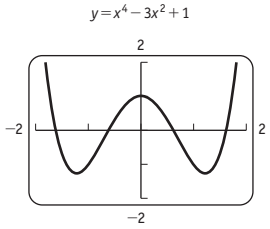
102. $k'(x)=-\frac{2}{x^3}$ is negative for all $x>0$.

103. $f'(x)=3x^2+a$; when $a\geq 0$, then the derivative is always nonnegative for all x, but when $a<0$, the derivative changes sign at least twice. **104.** $2x+1$ **105.** $2x$ **106.** $3x^2-1\ (x\neq 0)$

107. $3x^2-\frac{1}{x^2}\ (x\neq 0)$ **108.** $\frac{\sqrt{7}}{2\sqrt{x}}$ **109.** $\frac{2}{3\sqrt[3]{x^2}}$

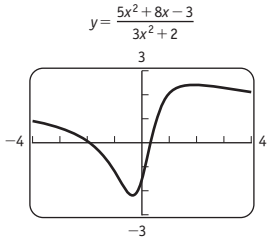
110. $1-\frac{1}{x^2}$ **111.** $3x^2+6x+3$ **112.** Left to the student

113.



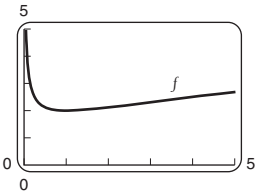
$x=-1.225, x=0, x=1.225$

114.



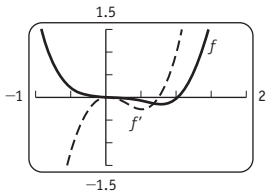
$x=-0.346, x=1.929$

115.



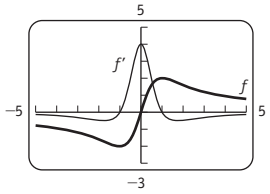
$x\approx 0.432$

116.



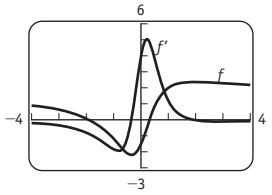
$f'(1)=1$

117.



$f'(1)=0$

118.



$f'(1)=1.2$

Technology Connection, p. 160

1. (c) **2–4.** Left to the student

Exercise Set 1.6, p. 162

1. $11x^{10}$ **2.** $13x^{12}$ **3.** $12x+7$ **4.** $24x-5$

5. $20x^4+60x^2$ **6.** $18x^5-60x^4$ **7.** $\frac{15}{2}x^{3/2}+4x$

8. $14x^{5/2}+9x^2$ **9.** $24x^2+12x+11$ **10.** $18x^2+14x-18$

11. $\frac{9\sqrt{t}}{2}-\frac{1}{2\sqrt{t}}+2$ **12.** $3\sqrt{t}+\frac{17}{2\sqrt{t}}+11$ **13.** $4x^3\ (x\neq 0)$

14. $2x\ (x\neq 0)$ **15.** $18x^5-2x\ (x\neq 0)$ **16.** $8x^3+1\ (x\neq 0)$

17. $2x-3\ (x\neq -3)$ **18.** $8x+2\ \left(x\neq \frac{1}{2}\right)$ **19.** $1\ (t\neq -4)$

20. $1\ (t\neq 5)$ **21.** $48x^3+3x^2+22x+17$

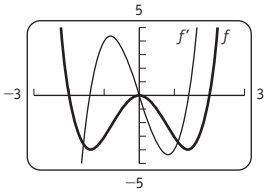
22. $40x^3-21x^2-26x+13$ **23.** $\frac{-10x^4+6x^2+30x}{(2x^3+3)^2}$

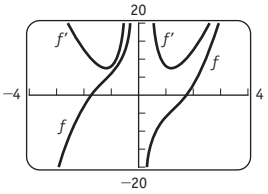
24. $\frac{3x^6-16x^3-2}{(x^3-1)^2}$ **25.** $120x^2+\frac{25}{2}x^{3/2}+\frac{3}{2}x^{-1/2}+24$

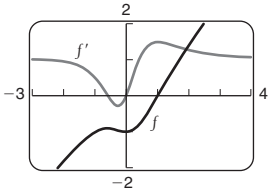
26. $-\frac{105}{2}x^{3/2}-6x+42x^{1/2}+4$ **27.** $\frac{3}{(3-t)^2}+15t^2$

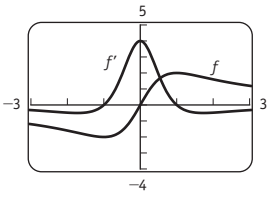
28. $\frac{5}{(5+2t)^2}-8t^3$ **29.** $2x+6$ **30.** $50x-40$

31. $2x(x^2-4)(3x^2-4)$ **32.** $4(3x-2)(3x^2-4x+5)$

33. $5 - 100x^{-3} + 30x^{-4}$
34. $-36x^{-2} - 120x^{-3} + 144x^{-4} - 72x^{-5}$
35. $3t^2 - 1 + \frac{6}{t^2}$ **36.** $18t^5 - 60t^3 - 3t^2 + 5\ (t \neq 0)$
37. $-\frac{x^4 + 3x^2 + 2x}{(x^3 - 1)^2} - 10x$ **38.** $\frac{x^4 + 3x^2 + 2x}{(x^2 + 1)^2} + 12x^2$
39. $\frac{-\sqrt{x} + 21x^{1/6} + 6}{6x^{2/3}(\sqrt{x} + 3)^2}$ **40.** $\frac{\sqrt{x} - 15x^{1/6} - 8}{6x^{2/3}(\sqrt[3]{x} - 5)^2}$
41. $\frac{x(x + 2)}{(x + 1)^2}$ **42.** $-\frac{2x}{(x^2 + 1)^2}$ **43.** $-\frac{1}{(t - 4)^2}$
44. $-\frac{1}{(t + 2)^2}$ **45.** $\frac{-2x^2 + 6x + 2}{(x^2 + 1)^2}$ **46.** $\frac{5x^2 - 6x + 5}{(x^2 - 1)^2}$
47. $-\frac{t^2 + 18t - 22}{(t^2 - 2t + 4)^2}$ **48.** $\frac{14t^2 + 4t + 6}{(-t^2 + 4t + 1)^2}$ **49. (a)** $y = \frac{1}{2}$; **(b)** $y = \frac{12}{25}x + \frac{7}{25}$ **50. (a)** $y = 2$; **(b)** $y = \frac{1}{2}x + 2$
51. (a) $y = 4x$; **(b)** $y = -2$ **52. (a)** $y = x + 5$; **(b)** $y = \frac{21}{4}x - \frac{21}{4}$ **53.** $-\$0.0925$/belt **54.** $-\$0.0579$/bottle
55. $-\$0.0153$/belt **56.** $-\$0.0074$/bottle **57.** \$0.0772/belt
58. \$0.0505/bottle **59.** \$1.64/vase **60.** \$1.95/skateboard
61. (a) $P'(t) = -\frac{1000t^2 - 4500}{(2t^2 + 9)^2}$; **(b)** 133,824 residents; **(c)** 1730 residents/yr; **(d)** 95,202 residents; **(e)** -1581 residents/yr
62. (a) $T'(t) = -\frac{4t^2 - 4}{(t^2 + 1)^2}$; **(b)** 100.2 degrees; **(c)** -0.48 degree/hr; **(d)** 98.77 degrees; **(e)** -0.0069 degree/hr
63. (a) 0; **(b)** $\frac{3}{4}$; **(c)** -2; **(d)** $-\frac{4}{3}$ **64. (a)** 0; **(b)** does not exist; **(c)** -4; **(d)** $\frac{3}{2}$ **65.** $\frac{15x^2 + 112x - 12}{2(5x^2 + 4)^2}$ **66.** $30t^2 + 10t - 15$
67. $72x^7 + 108x^5 - 30x^4 + 84x^3 + 84x - 14$
68. $\frac{3x^6 - 4x^4 - 3x^2 + 32x}{(x^2 - 1)^2}$ **69. (a)** $\frac{1}{(x + 1)^2}$; **(b)** $\frac{1}{(x + 1)^2}$; **(c)** answers may vary. **70. (a)** $-\frac{2x}{(x^2 - 1)^2}$; **(b)** $-\frac{2x}{(x^2 - 1)^2}$; **(c)** answers may vary. **71.** Answers may vary. **72.** Answers may vary. **73. (a)** $\frac{dR}{dQ} = -Q^2 + kQ$; **(b)** answers may vary.
74. (a) Definition of derivative; **(b)** adding and subtracting same quantity; **(c)** the limit of the sum is the sum of the limits; **(d)** factoring; **(e)** the limit of a product is the product of the limits and evaluating $\lim_{h \to 0} f(x + h)$ and $\lim_{h \to 0} g(x + h)$; **(f)** definition of the derivative; **(g)** using Leibniz notation
75. \$0.79/bottle; \$0.0024/bottle at $x = 328$ **76.** \$13.24/belt; \$0.078/belt at $x = 169$
77. 

$(0, 0), (-1.414, -4), (1.414, -4)$,
78. 

none
79. 

$(-0.596, -0.894), (0, -1)$
80. 

$(-1, -2), (1, 2)$ **81.** y_3

Exercise Set 1.7, p. 171

1. $8x - 12$ **2.** $8x + 4$ **3.** $-55(7 - x)^{54}$ **4.** $-100(8 - x)^{99}$
5. $\frac{3x}{\sqrt{3x^2 - 4}}$ **6.** $\frac{4x}{\sqrt{4x^2 + 1}}$ **7.** $-\frac{1}{2\sqrt{1 - x}}$ **8.** $\frac{4}{\sqrt{1 + 8x}}$
9. $-400x(4x^2 + 1)^{-51}$ **10.** $-640x(8x^2 - 6)^{-41}$
11. $4(x - 4)^7(2x + 3)^5(7x - 6)$
12. $(x + 5)^6(4x - 1)^9(68x + 193)$ **13.** $-\frac{8}{(4x + 5)^3}$
14. $-\frac{6}{(3x + 8)^3}$ **15.** $\frac{4x(5x + 14)}{(7 - 5x)^4}$ **16.** $\frac{42x^2(3x + 2)}{(4 - 9x)^6}$
17. $-5(2x - 3)^3(10x - 3)$ **18.** $-3(5x + 4)^5(35x + 4)$
19. $4(5x + 2)^3(2x - 3)^7(30x - 7)$
20. $(3x - 1)^6(2x + 1)^4(72x + 11)$ **21.** $\frac{2x(5x - 1)}{\sqrt{4x - 1}}$
22. $\frac{x^2(35x + 12)}{2\sqrt{5x + 2}}$ **23.** $\frac{2x - 5}{4(x^2 - 5x + 2)^{3/4}}$ **24.** $\frac{5x^4 + 6}{3x^{2/3}(x^4 + 6)^{2/3}}$
25. $\frac{44(3x - 1)^3}{(5x + 2)^5}$ **26.** $-\frac{24x^2(x^2 - 1)}{(x^2 + 1)^4}$ **27.** $-\frac{5(7x - 2)^4}{(3x - 1)^6}$
28. $\frac{68(5x - 1)^3}{(2x + 3)^5}$ **29.** $\frac{(5x - 4)^6(120x + 107)}{(6x + 1)^4}$
30. $-\frac{(2x + 3)^3(6x + 61)}{(3x - 2)^6}$ **31.** $\frac{13}{2\sqrt{(2x + 3)(5 - x)^3}}$
32. $-\frac{7}{2\sqrt{(x + 3)^3(4 - x)}}$ **33.** $-\frac{45}{u^4}, 2, -\frac{90}{(2x + 1)^4}$
34. $\frac{1}{2\sqrt{u}}, 2x, \frac{x}{\sqrt{x^2 - 1}}$
35. $50u^{49}, 12x^2 - 4x, 200x(4x^3 - 2x^2)^{49}(3x - 1)$

36. $-\frac{2}{(u-1)^2}, \frac{1}{2\sqrt{x}}, -\frac{1}{x^{3/2}}$ **37.** $3x^2(10x^3+13)$

38. $2x(x^2+3)(3x^2-5)$ **39.** $\frac{-6t-11}{3(t+2)^2(3t+5)^2}$

40. $-\frac{210t(7t^2+1)^4}{(3(7t^2+1)^5-7)^2}$ **41.** $y=0$ **42.** $y=\frac{5}{4}x+\frac{3}{4}$

43. $y=4x-3$ **44.** $y=-735x+1813$ **45. (a)** $-\frac{64(6x+1)}{(2x-5)^3}$; **(b)** same as in part (a); **(c)** answers may vary. **46. (a)** $\frac{2x-3x^2}{(1+x)^6}$; **(b)** same as in part (a); **(c)** they are the same. **47.** -216 **48.** $-\frac{1}{2}$

49. $\frac{4}{\sqrt[3]{169}}$, or about 0.72 **50.** $-\frac{70(13)^4}{6^6}$, or about -42.85

51. (a) $f(x)=x^5, g(x)=3x^2+2x$; **(b)** 4,587,520

52. (a) $f(x)=\sqrt{x}, g(x)=1+5x^2$; **(b)** $\frac{20}{9}$

53. (a) $f(x)=\frac{x+1}{x+4}; g(x)=x^3$; **(b)** $\frac{9}{25}$

54. (a) $f(x)=\frac{1}{x}; g(x)=x^2+2x$; **(b)** $\frac{4}{9}$

55. $6(2x^3+(4x-5)^2)^5(6x^2+8(4x-5))$

56. $3\left(-x^5+4x+\sqrt{2x+1}\right)^2\left(-5x^4+4+\frac{1}{\sqrt{2x+1}}\right)$

57. $\frac{1}{2\sqrt{x^2+\sqrt{1-3x}}}\left(2x-\frac{3}{2\sqrt{1-3x}}\right)$

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

59. \$1,000,000/airplane **60.** \$489,574/airplane

61. \$510,429/airplane **62.** \$44,700/month

63. (a) $\frac{dA}{dr}=5000\left(1+\frac{r}{4}\right)^{19}$; units are dollars per interest rate. **(b)** It is the rate of change in the amount as the interest rate r changes.

64. (a) $\frac{dA}{dr}=3000\left(1+\frac{r}{12}\right)^{35}$; units are dollars per interest rate. **(b)** It is the rate of change in the amount as the interest rate r changes.

65. (a) $P(t)=2t^2+400.8t+80.08$; **(b)** \$592.80/month

66. (a) $D(t)=\frac{80{,}000}{1.6t+9}$; **(b)** -4.482 units/day

67. (a) $D(c)=4.25c+106.25, c(w)=\frac{95w}{43.2}=2.199w$; **(b)** 4.25 mg/unit of creatine clearance; **(c)** 2.199 units of creatine clearance/kg; **(d)** 9.35 mg/kg; **(e)** it is the rate of change in dosage as the patient's weight, in kilograms, varies. **68. (a)** About 15.75, which means that an object with a weight of 100 kg at sea level has an equivalent weight of 15.75 stone; **(b)** 0.157, which means that an object's weight increases by 0.157 stone per kilogram. **69. (a)** $(F\circ C)(3000)=F(C(3000))=F(86.67)=188$, which means that water at 3000 m boils at 188°F; **(b)** -0.008, which means that at 3000 m in altitude, the boiling point of water drops by 0.008°F/m as altitude increases. **70. (a)** 36.35, which means that a woman with a 9-in. foot wears a size 36.35 shoe in Europe; **(b)** 4.05, which means that for every inch a woman's foot grows, her European shoe size increases by 4.05 units per inch.

71. $4x(x^2+1)$ **72.** $1+\frac{1}{2\sqrt{x}}+\frac{1}{2\sqrt{x+\sqrt{x}}}\left(1+\frac{1}{2\sqrt{x}}\right)$

73. $8x((x^2+1)^2+1)(x^2+1)$ **74.** $\frac{1}{27}x^{-26/27}$

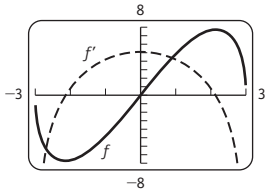
75. $\frac{6x^7+32x^5+5x^4}{(x^3+6x+1)^{2/3}}$ **76.** $(3x^2+6x^4)\sqrt{1+x^2}$

77. $\frac{1}{(1-x)\sqrt{1-x^2}}$ **78.** $\frac{3(x^2-x-1)^2(x^2+4x-1)}{(x^2+1)^4}$

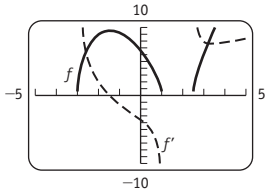
79. $\frac{x^2+x-2}{\sqrt{(2x+1)^3(x^2-4x)}}$ **80.** $\frac{6\sqrt{t}+1}{4\sqrt{t}\sqrt{3t+\sqrt{t}}}$

81. $-72(6x(3-x)^5+2)^3(3-x)^4(2x-1)$ **82. (a)** Rewriting $\frac{1}{g(x)}=[g(x)]^{-1}$; **(b)** using Leibniz notation, differentiating both sides; **(c)** using the Product Rule for differentiation; **(d)** using the Extended Power Rule; **(e)** simplifying by moving negative powers to the denominator; **(f)** multiplying the second fraction by $\frac{g(x)}{g(x)}=1$; **(g)** writing over a common denominator and simplifying.

83. Left to the student

84. 

(−2.14476, −7.728), (2.14476, 7.728)

85. 

(−1.47481, 9.4878)

Exercise Set 1.8, p. 179

1. $20x^3$ **2.** $12x^2$ **3.** $30x$ **4.** $24x^2$ **5.** 8 **6.** 8 **7.** 0

8. 0 **9.** $\frac{6}{x^4}$ **10.** $\frac{12}{x^5}$ **11.** $-\frac{3}{16x^{7/4}}$ **12.** $-\frac{1}{4x^{3/2}}$

13. $12x^2+\frac{6}{x^3}$ **14.** $6x-\frac{10}{x^3}$ **15.** $-\frac{2}{9x^{5/3}}$ **16.** $-\frac{4}{25x^{9/5}}$

17. $\frac{48}{x^5}$ **18.** $\frac{12}{x^4}$ **19.** $6(x^3+2x)^4(51x^4+72x^2+20)$

20. $14(x^2+3x)^5(13x^2+39x+27)$ **21.** $\frac{3(x^2+2)}{4(x^2+1)^{5/4}}$

22. $\frac{4(x^2-3)}{9(x^2-1)^{4/3}}$ **23.** $\frac{3}{4\sqrt{x}}$ **24.** $-\frac{2}{9x^{4/3}}$

25. $\frac{45x^4-54x^2-3}{16(x^3-x)^{5/4}}$ **26.** $\frac{40x^6+56x^3-2}{9(x^4+x)^{4/3}}$

27. $\frac{44}{(2x-3)^3}$ **28.** $\frac{170}{(5x-1)^3}$ **29.** $120x$ **30.** 24

31. $720x$ **32.** $5040x$ **33.** $-\frac{2520}{x^8}+\frac{1760}{243x^{14/3}}$

34. $\frac{120}{x^6}+\frac{15}{16x^{7/2}}$ **35. (a)** $v(t)=3t^2+1$; **(b)** $a(t)=6t$; **(c)** 49 ft/sec, 24 ft/sec^2 **36. (a)** $v(t)=-20t+2$; **(b)** $a(t)=-20$; **(c)** -18 m/sec, -20 m/sec^2

37. (a) $v(t)=2t-\frac{1}{2}$; **(b)** $a(t)=2$; **(c)** 1.5 m/sec, 2 m/sec^2

38. **(a)** $v(t) = 3$; **(b)** $a(t) = 0$; **(c)** 3 mi/hr, 0 mi/hr^2; **(d)** answers may vary. **39.** **(a)** 144 ft; **(b)** 96 ft/sec; **(c)** 32 ft/sec^2 **40.** **(a)** 64 ft; **(b)** 64 ft/sec; **(c)** 32 ft/sec^2

41. 19.6 m/sec, 9.8 m/sec^2 **42.** 29.4 m/sec, 9.8 m/sec^2

43. **(a)** At a time t near 0, since the slope is steepest there; **(b)** negative, since the slopes of the tangent lines are decreasing

44. **(a)** At $t = 20$ sec, since the slope of the tangent line is steeper; **(b)** positive, since the slopes of the tangent lines are increasing

45. **(a)** $(7, 11)$; **(b)** $(2, 4)$, $(7, 11)$, and $(13, 15)$; **(c)** $(0, 2)$ and $(11, 13)$; **(d)** $(4, 7)$; **(e)** answers may vary.

46. **(a)** $(0, 2)$ and $(8, 9)$; **(b)** $(4, 5)$ and $(11, 13)$; **(c)** $(2, 4)$, $(5, 8)$, $(9, 11)$, and $(13, 18)$ **47.** **(a)** \$146,000/month, \$84,000/month, −\$4000/month; **(b)** −\$68,000/month^2, −\$56,000/month^2, −\$32,000/month^2; **(c)** answers may vary.

48. **(a)** 2 pendants/day, 14 pendants/day, 74 pendants/day; **(b)** 6 pendants/day^2, 18 pendants/day^2, 42 pendants/day^2; **(c)** answers may vary. **49.** **(a)** 11.34, 1.98, 0.665; **(b)** −0.789, −0.0577, −0.0112; **(c)** answers may vary.

50. **(a)** 1.2%/min, 0%/min, −0.0888%/min, −0.0028%/min; **(b)** −3.52%/min^2, −1.25%/min^2, 0.031%/min^2, 0.00018%/min^2; **(c)** answers may vary. **51.** **(a)** Height: 74.7 m, horizontal distance: 54.5 m; **(b)** vertical: 2.55 m/sec, horizontal: 27.25 m/sec; **(c)** vertical: −9.8 m/sec^2, horizontal: 0; **(d)** it is moving upward, since $v(2) > 0$; **(e)** and **(f)** answers may vary. **52.** **(a)** Height: 5.1 m, horizontal distance: 2 m; **(b)** vertical: −9.8 m/sec, horizontal: 2 m/sec; **(c)** vertical: −9.8 m/sec^2, horizontal: 0; **(d)** answers may vary.

53. Graph I **54.** Graph IV **55.** Graph II **56.** Graph III

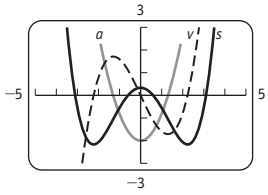
57. False **58.** True **59.** False **60.** $f'(x) = -\dfrac{1}{x^2}$, $f''(x) = \dfrac{2}{x^3}, f'''(x) = -\dfrac{6}{x^4}, f^{(4)} = \dfrac{24}{x^5}$. Signs alternate, and odd-order derivatives are negative. The denominator's power is always one higher than the order of the derivative. The numerator is −1 for the 1st derivative, $(-1)(-2) = 2$ for the 2nd derivative, $(-1)(-2)(-3) = -6$ for the 3rd derivative, and so on. Thus, the 12th derivative will have $(-1)(-2)(-3)\cdots(-11)(-12) =$ 479,001,600 as the numerator. $f^{(12)}(x) = \dfrac{479{,}001{,}600}{x^{13}}$.

61. $f'(x) = \dfrac{3}{(x+2)^2}, f''(x) = -\dfrac{6}{(x+2)^3}, f'''(x) = \dfrac{18}{(x+2)^4}, f''''(x) = -\dfrac{72}{(x+2)^5}$ **62.** $f'(x) = -\dfrac{5}{(x-2)^2}, f''(x) = \dfrac{10}{(x-2)^3}, f'''(x) = -\dfrac{30}{(x-2)^4}, f''''(x) = \dfrac{120}{(x-2)^5}$

63. **(a)** 3.24 m; **(b)** 3.24 m/sec; **(c)** 1.62 m/sec^2; **(d)** it is the gravitational constant on the moon. **64.** Answers may vary. Maximum is probably around 1.1 sec, but this would require a near-record vertical leap. **65.** 42.33 ft/sec **66.** Answers may vary. **67.** **(a)** $6 < x < 8$; **(b)** $3 < x < 6$; **(c)** $10 < x < 12$; **(d)** $8 < x < 10$; **(e)** $8 < x < 12$; **(f)** answers may vary.

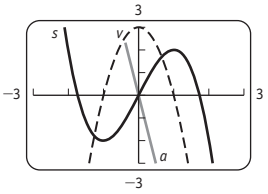
68. **(a)** $0 < x < 9$; **(b)** $0 < x < 4$ or $10.5 < x < 12$; **(c)** $4 < x < 6$; **(d)** $9 < x < 12$; **(e)** answers may vary.

69.



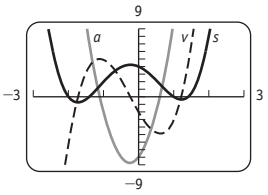
At $t \approx -1.29, 1.29$

70.



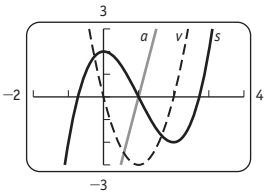
At $t = 0$

71.



At $t \approx -1.104, 0.604$

72.

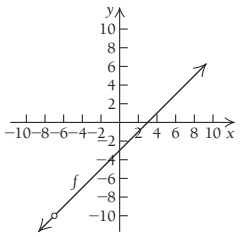


At $t = 1$

Chapter 1 Review Exercises, p. 188

1. False **2.** False **3.** True **4.** False **5.** True **6.** True **7.** False **8.** True **9.** (e) **10.** (c) **11.** (a) **12.** (f) **13.** (b) **14.** (d) **15.** **(a)** −10.1, −10.01, −10.001 and −9.9, −9.99, −9.999; **(b)** −10, −10, −10

16.



$\lim_{x \to -7} f(x) = -10$

17. $\dfrac{x^2 + 4x - 21}{x + 7} = \dfrac{(x+7)(x-3)}{x+7} = x - 3$, for $x \neq -7$. Thus, $\lim_{x \to -7}(x - 3) = -10$. **18.** −4 **19.** 10 **20.** −12 **21.** 3 **22.** 4 **23.** Does not exist **24.** −4 **25.** −4 **26.** Yes, since $\lim_{x \to 1} g(x) = g(1)$ **27.** Does not exist **28.** −2 **29.** No, since $\lim_{x \to -2} g(x)$ does not exist **30.** No **31.** $-\frac{2}{3}$ **32.** 0 **33.** Not defined at $x = -2$, since g is discontinuous there **34.** Not defined at $x = -2$, since there is a corner there **35.** −2 **36.** −3 **37.** Yes, since $\lim_{x \to -2} f(x) = f(-2)$ **38.** Yes **39.** 2 **40.** $-6x - 3h, h \neq 0$ **41.** $y = x - 1$ **42.** $(4, 5)$ **43.** $45x^4$ **44.** $\dfrac{8}{3}x^{-2/3}$ **45.** $\dfrac{24}{x^9}$ **46.** $6x^{-3/5}$

47. $0.7x^6 - 12x^3 - 3x^2$ **48.** $\dfrac{5}{2}x^5 + 32x^3 - 2$

49. $(x^3 + 5)\left(\dfrac{1}{2\sqrt{x}} + 4\right) + (\sqrt{x} + 4x)(3x^2)$

50. $\dfrac{-x^2 + 16x + 8}{(8 - x)^2}$ **51.** $2(5 - x)(2x - 1)^4(26 - 7x)$

52. $35x^4(x^5 - 3)^6$ **53.** $\dfrac{11x^2 + 4x}{(4x + 2)^{1/4}}$ **54.** $-48x^{-5}$

55. $3x^5 - 60x + 26$ **56.** **(a)** $P'(t) = 100t$; **(b)** 30,000 people; **(c)** 2000 people/yr **57.** $(3, 5), (7, 8), (9, 13), (15, 18)$ **58.** $(7, 8), (15, 18)$ **59.** $(0, 3), (8, 9)$ **60.** $(5, 7), (13, 15)$

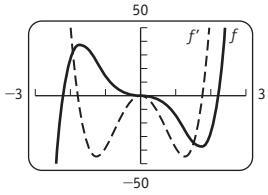
61. **(a)** 656 ft; **(b)** −96 ft/sec; **(c)** −32 ft/sec^2; **(d)** −226.27 ft/sec; **(e)** answers may vary.

62. **(a)** $\overline{C} = \dfrac{5\sqrt{x} + 100}{x}$, $\overline{R} = 40$, $\overline{P} = 40 - \dfrac{5\sqrt{x} + 100}{x}$; **(b)** −$1.33/lamp

63. $\dfrac{d}{dx}(f \circ g)(x) = -4(1 - 2x)$; $\dfrac{d}{dx}(g \circ f)(x) = -4x$

64. $\dfrac{-9x^4 - 4x^3 + 9x + 2}{2\sqrt{1 + 3x}(1 + x^3)^2}$

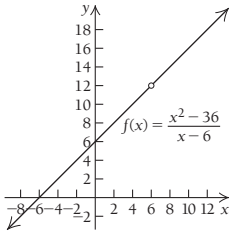
65. $\dfrac{1}{243}x^{-242/243}$ **66.** −0.25 **67.** $\frac{1}{6}$

68. 

(−1.7137, 37.445), (0, 0), (1.7137, −37.445)

Chapter 1 Test, p. 190

1. **(a)** 11.9, 11.99, 11.999 and 12.1, 12.01, 12.001; **(b)** 12, 12, 12

2. 

$\lim_{x \to 6} f(x) = 12$

3. $\dfrac{x^2 - 36}{x - 6} = \dfrac{(x + 6)(x - 6)}{x - 6} = x + 6, x \neq 6.$ Thus, $\lim_{x \to 6}(x + 6) = 12$ **4.** Does not exist **5.** 0 **6.** Does not exist **7.** 2 **8.** 4 **9.** 1 **10.** 1 **11.** 2 **12.** 0 **13.** 0 **14.** −5, −3, −2, 1, 4 **15.** −5, −3, −2, −1, 1, 3, 4 **16.** Continuous **17.** Not continuous, since $\lim_{x \to 3} f(x)$ does not exist **18.** **(a)** Does not exist; **(b)** 1; **(c)** no **19.** 3 **20.** 6 **21.** $\frac{1}{8}$ **22.** Does not exist, since the left-hand limit does not equal the right-hand limit **23.** $4x + 3 + 2h$

24. $y = \dfrac{3}{4}x + 2$ **25.** (0, 0), (2, −4) **26.** $23x^{22}$

27. $\dfrac{4}{3}x^{-2/3} + \dfrac{5}{2}x^{-1/2}$ **28.** $\dfrac{10}{x^2}$ **29.** $\dfrac{5}{4}x^{1/4}$ **30.** $-x + 0.61$

31. $x^2 - 2x + 2$ **32.** $\left(3\sqrt{x} + 1\right)(2x - 1) + (x^2 - x)\left(\dfrac{3}{2\sqrt{x}}\right)$

33. $\dfrac{5}{(5 - x)^2}$ **34.** $(x + 3)^3(7 - x)^4(13 - 9x)$

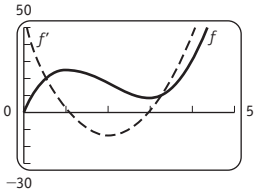
35. $-5(x^5 - 4x^3 + x)^{-6}(5x^4 - 12x^2 + 1)$ **36.** $\dfrac{2x^2 + 5}{\sqrt{x^2 + 5}}$

37. $24x$ **38.** **(a)** $M'(t) = -0.003t^2 + 0.2t$; **(b)** 9 words; **(c)** 1.7 words/min

39. **(a)** $\overline{R} = 50$, $\overline{C} = \dfrac{x^{2/3} + 750}{x}$, $\overline{P} = 50 - \dfrac{x^{2/3} + 750}{x}$; **(b)** −$11.74/speaker

40. $24x^5 - 6x^2$ **41.** $6(x^2 - x)^2(2x - 1)$ **42.** Graph A

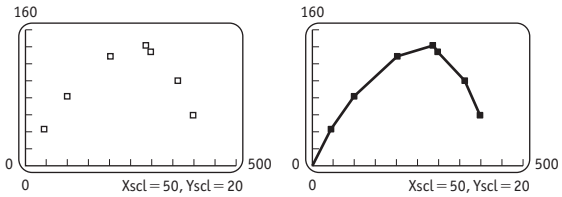
43. $-\dfrac{1 + 9x}{2(1 - 3x)^{2/3}(1 + 3x)^{5/6}}$ **44.** 27

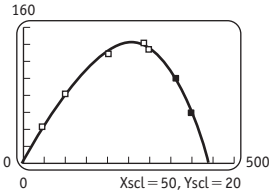
45. 

(1.0835, 25.1029), (2.9502, 8.6247)

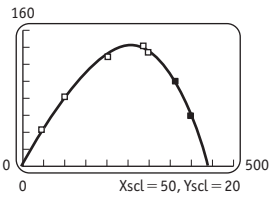
46. 0.5

Extended Technology Application, p. 192

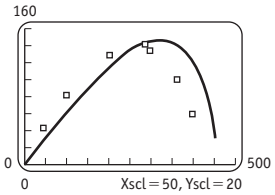
1. 

2. **(a)** $y = -0.0000045x^3 + 0.000204x^2 + 0.7806x + 4.6048$; **(b)** 

(c) acceptable fit; **(d)** about 441 ft; **(e)** $y' = -0.0000135x^2 + 0.000408x + 0.7806$; **(f)** at about (256, 142), meaning that the ball reached a maximum height of 142 ft at 256 ft from home plate.

3. **(a)** $y = -0.0000000024x^4 - 0.0000026x^3 - 0.00026x^2 + 0.815x + 4.3026$; **(b)** 

(c) acceptable fit; **(d)** about 440 feet; **(e)** $y' = -0.0000000096x^3 - 0.0000078x^2 - 0.00053x + 0.815$; **(f)** at about (257, 142), meaning that the ball reached a maximum height of 142 ft at 257 ft from home plate.

4. **(a)** 

(b) 450 ft; **(c)** $y' = \dfrac{303.75 - 0.003x^2}{\sqrt{202{,}500 - x^2}}$; **(d)** at about (318, 152), meaning that the ball reached a maximum height of 152 ft at 318 ft from home plate. **5.** The two models are similar; the main difference is that the maximum height is reached farther from home plate using the model in Exercise 4. **6.** 466 ft, 442 ft, 430 ft **7.** Left to the student **8.** **(a)** 523 ft; **(b)** 490 ft, 450 ft; **(c)** 551 ft