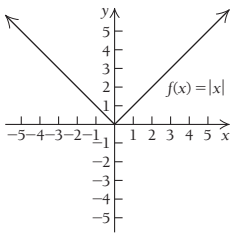
Calculus and Its Applications Brief Version 12th edition Bittinger Solutions Manual

SKU: 9780135164884-SOLUTIONS

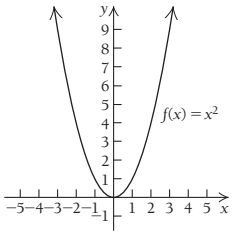
INSTRUCTOR ANSWERS: CHAPTER 1

Exercise Set 1.1, p. 112

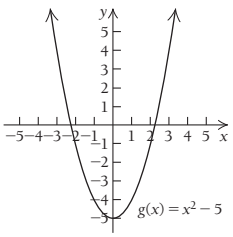
1. $0.3, x \to 0.3^-$ **2.** $1.7, x \to 1.7^+$ **3.** $-3, x \to -3^-$
4. $-4.9, x \to -4.9^+$ **5.** $\frac{2}{3}, x \to \left(\frac{2}{3}\right)^-$ **6.** $\frac{4}{3}, x \to \left(\frac{4}{3}\right)^-$
7. $0.3, x \to 0.3^-$ **8.** $1.2, x \to 1.2^-$ **9.** $1, x \to 1^+$
10. $0, x \to 0^-$ **11.** -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.


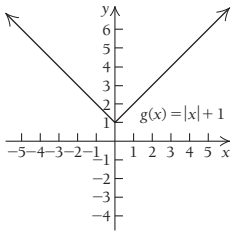
0, 2

62.


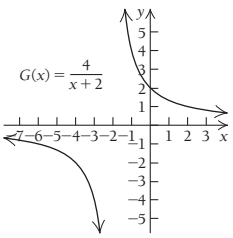
1, 0

63.


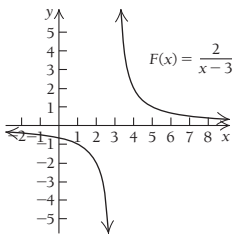
$-5, -4$

64.


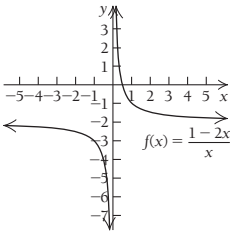
4, 1

65.


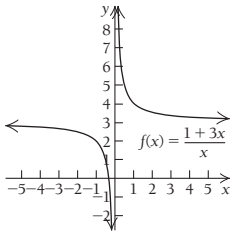
4, does not exist

66.


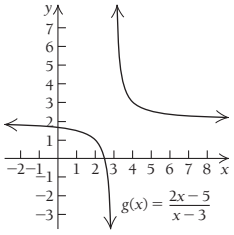
does not exist, 2

67.


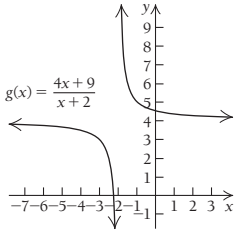
-2, does not exist

68.


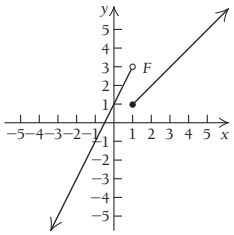
3, does not exist

69.


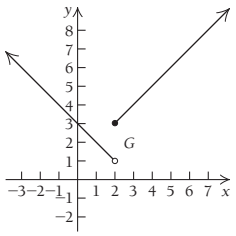
2, does not exist

70.


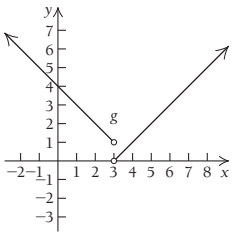
4, does not exist

71.


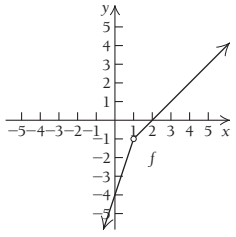
3, 1, does not exist

72.


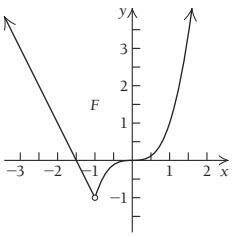
1, 3, does not exist

73.


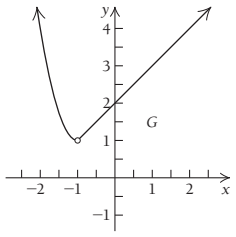
1, 0, does not exist

74.


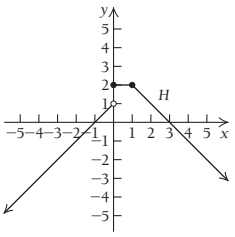
$-1, -1, -1$

75.


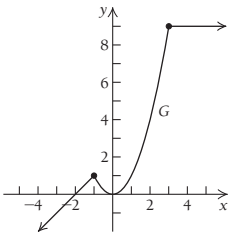
-1

76.


1

77.


does not exist, 2

78.


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, $\frac{1}{6}$

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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

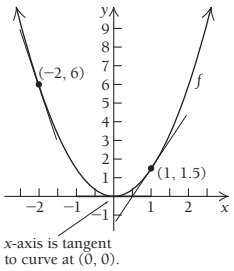
1. The temperature rose 3 degrees/hr. **2.** Jennifer hiked 3 mi/hr. **3.** Marcus delivered 7 packages/hr. **4.** The population of Felton grew by 100 people/yr. **5.** Tanya scored 25 points/game. **6.** Chris grew 7.5 cm/yr. **7.** Burnham Industries had 5,000,000 dollars/month in revenue. **8.** 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;

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

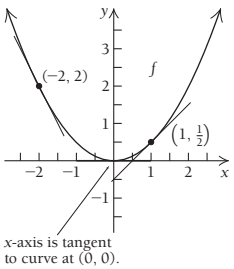
Exercise Set 1.4, p. 144

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



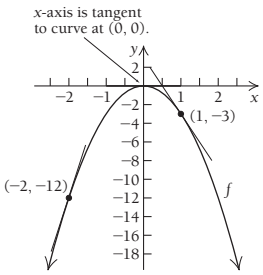
(c) $f'(x) = 3x$; **(d)** $-6, 0, 3$

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



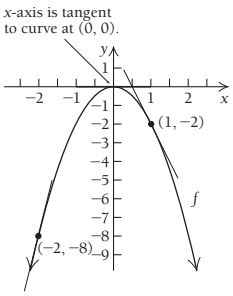
(c) $f'(x) = x$; **(d)** $-2, 0, 1$

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



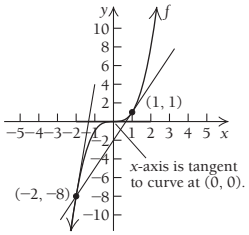
(c) $f'(x) = -6x$; **(d)** $12, 0, -6$

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



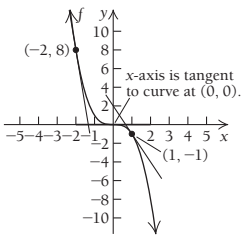
(c) $f'(x) = -4x$; **(d)** $8, 0, -4$

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



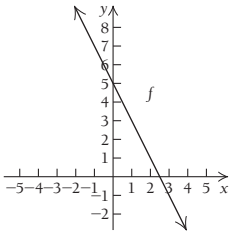
(c) $f'(x) = 3x^2$; **(d)** $12, 0, 3$

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



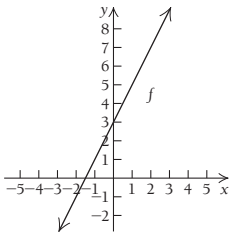
(c) $f'(x) = -3x^2$; **(d)** $-12, 0, -3$

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



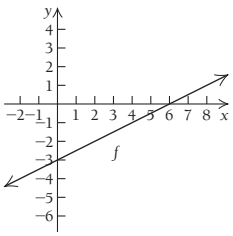
(c) $f'(x) = -2$; **(d)** $-2, -2, -2$

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



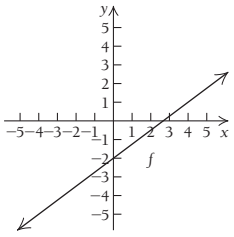
(c) $f'(x) = 2$; **(d)** $2, 2, 2$

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



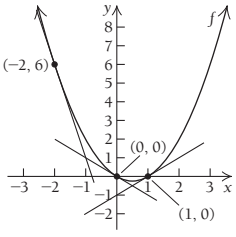
(c) $f'(x) = \frac{1}{2}$; **(d)** $\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$

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



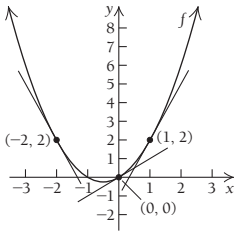
(c) $f'(x) = \frac{3}{4}$; **(d)** $\frac{3}{4}, \frac{3}{4}, \frac{3}{4}$

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

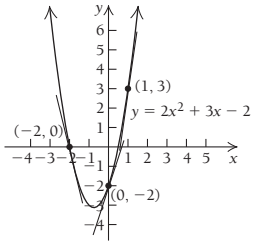


(c) $f'(x) = 2x - 1$; **(d)** $-5, -1, 1$

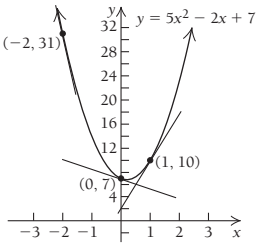
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12. **(a)** and **(b)** 

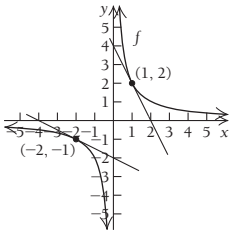
(c) $f'(x) = 2x + 1$; **(d)** $-3, 1, 3$

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

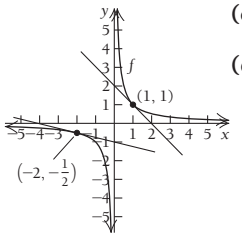
(c) $f'(x) = 4x + 3$; **(d)** $-5, 3, 7$

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.** $\dfrac{1}{7} - \dfrac{7}{x^2}$

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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.

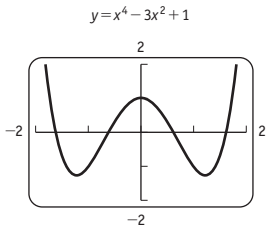
102. $k'(x)=-\frac{2}{x^3}$ is negative for all $x>0$.

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.** $\frac{2}{3\sqrt[3]{x^2}}$

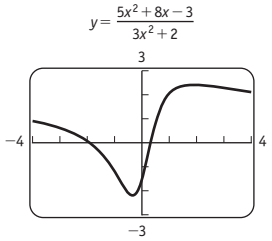
110. $1-\frac{1}{x^2}$ **111.** $3x^2+6x+3$ **112.** Left to the student

113.



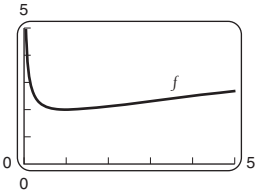
$x=-1.225, x=0, x=1.225$

114.



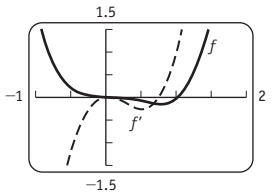
$x=-0.346, x=1.929$

115.



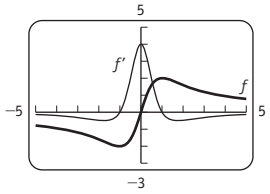
$x\approx 0.432$

116.



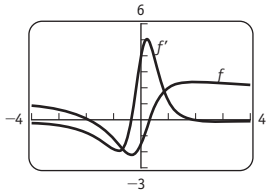
$f'(1)=1$

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.** $\frac{-10x^4+6x^2+30x}{(2x^3+3)^2}$

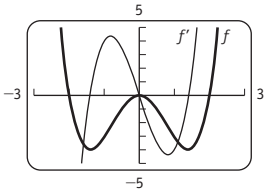
24. $\frac{3x^6-16x^3-2}{(x^3-1)^2}$ **25.** $120x^2+\frac{25}{2}x^{3/2}+\frac{3}{2}x^{-1/2}+24$

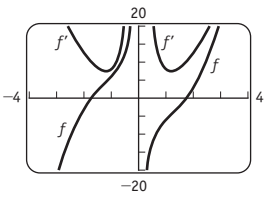
26. $-\frac{105}{2}x^{3/2}-6x+42x^{1/2}+4$ **27.** $\frac{3}{(3-t)^2}+15t^2$

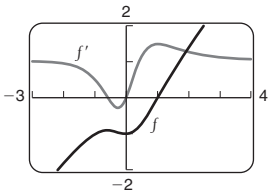
28. $\frac{5}{(5+2t)^2}-8t^3$ **29.** $2x+6$ **30.** $50x-40$

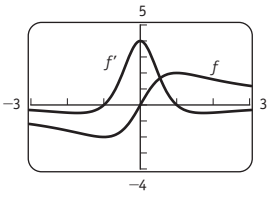
31. $2x(x^2-4)(3x^2-4)$ **32.** $4(3x-2)(3x^2-4x+5)$

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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. $50u^{49}, 12x^2 - 4x, 200x(4x^3 - 2x^2)^{49}(3x - 1)$

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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.** $\frac{1}{27}x^{-26/27}$

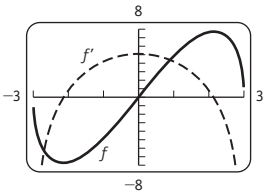
75. $\frac{6x^7+32x^5+5x^4}{(x^3+6x+1)^{2/3}}$ **76.** $(3x^2+6x^4)\sqrt{1+x^2}$

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

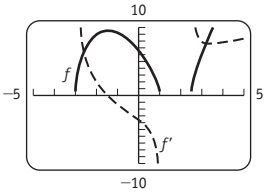
79. $\frac{x^2+x-2}{\sqrt{(2x+1)^3(x^2-4x)}}$ **80.** $\frac{6\sqrt{t}+1}{4\sqrt{t}\sqrt{3t+\sqrt{t}}}$

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

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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.

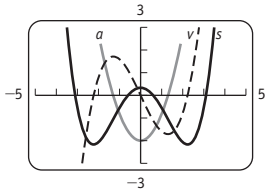
53. Graph I **54.** Graph IV **55.** Graph II **56.** Graph III

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. $f^{(12)}(x) = \dfrac{479{,}001{,}600}{x^{13}}$.

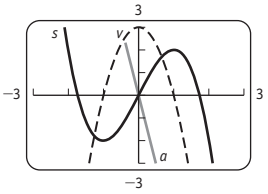
61. $f'(x) = \dfrac{3}{(x+2)^2}, f''(x) = -\dfrac{6}{(x+2)^3}, f'''(x) = \dfrac{18}{(x+2)^4}, f''''(x) = -\dfrac{72}{(x+2)^5}$ **62.** $f'(x) = -\dfrac{5}{(x-2)^2}, f''(x) = \dfrac{10}{(x-2)^3}, f'''(x) = -\dfrac{30}{(x-2)^4}, f''''(x) = \dfrac{120}{(x-2)^5}$

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.

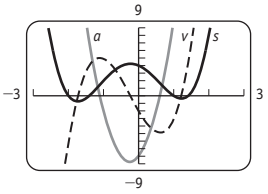
68. **(a)** $0 < x < 9$; **(b)** $0 < x < 4$ or $10.5 < x < 12$; **(c)** $4 < x < 6$; **(d)** $9 < x < 12$; **(e)** answers may vary.

69. 

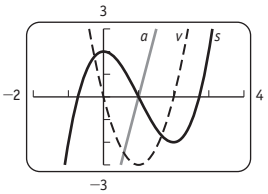
At $t \approx -1.29, 1.29$

70. 

At $t = 0$

71. 

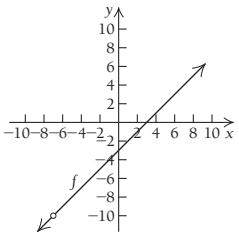
At $t \approx -1.104, 0.604$

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.** $(5, 7), (13, 15)$

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

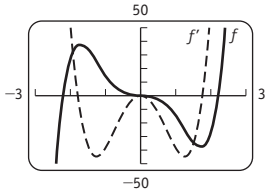
62. **(a)** $\overline{C} = \dfrac{5\sqrt{x} + 100}{x}$, $\overline{R} = 40$, $\overline{P} = 40 - \dfrac{5\sqrt{x} + 100}{x}$; **(b)** −$1.33/lamp

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.

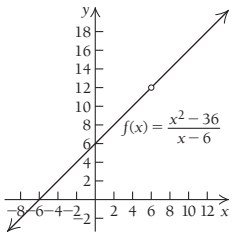


(−1.7137, 37.445), (0, 0), (1.7137, −37.445)

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.** $(x + 3)^3(7 - x)^4(13 - 9x)$

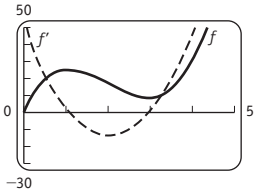
35. $-5(x^5 - 4x^3 + x)^{-6}(5x^4 - 12x^2 + 1)$ **36.** $\dfrac{2x^2 + 5}{\sqrt{x^2 + 5}}$

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.

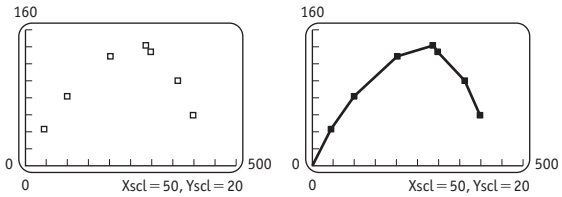


(1.0835, 25.1029), (2.9502, 8.6247)

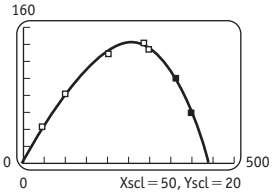
46. 0.5

Extended Technology Application, p. 192

1.

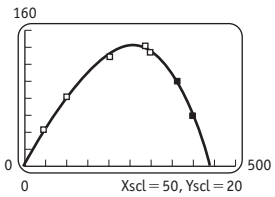


2. **(a)** $y = -0.0000045x^3 + 0.000204x^2 + 0.7806x + 4.6048$; **(b)**



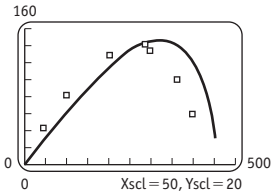
(c) acceptable fit; **(d)** about 441 ft; **(e)** $y' = -0.0000135x^2 + 0.000408x + 0.7806$; **(f)** at about (256, 142), meaning that the ball reached a maximum height of 142 ft at 256 ft from home plate.

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

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