Chapter 1

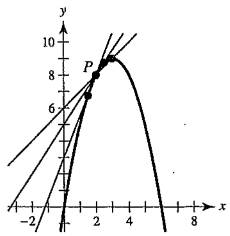
Section 1.1 (page 47)

1. Precalculus: 300 ft

3. Calculus: Slope of the tangent line at $x = 2$ is 0.16.

5. (a) Precalculus: 10 square units (b) Calculus: 5 square units

7. (a)



(b) $1; \frac{3}{2}; \frac{5}{2}$

(c) 2. Use points closer to P.

9. (a) Area ≈ 10.417; Area ≈ 9.145 (b) Use more rectangles.

11. (a) 5.66 (b) 6.11 (c) Increase the number of line segments.

Section 1.2 (page 54)

1.

x	3.9	3.99	3.999	4.001	4.01	4.1
$f(x)$	0.2041	0.2004	0.2000	0.2000	0.1996	0.1961

$$\lim_{x \to 4} \frac{x-4}{x^2-3x-4} \approx 0.2000 \left(\text{Actual limit is } \frac{1}{5}.\right)$$

3.

x	−0.1	−0.01	−0.001	0.001	0.01	0.1
$f(x)$	0.2050	0.2042	0.2041	0.2041	0.2040	0.2033

$$\lim_{x \to 0} \frac{\sqrt{x+6}-\sqrt{6}}{x} \approx 0.2041 \left(\text{Actual limit is } \frac{1}{2\sqrt{6}}.\right)$$

5.

x	2.9	2.99	2.999
$f(x)$	−0.0641	−0.0627	−0.0625

x	3.001	3.01	3.1
$f(x)$	−0.0625	−0.0623	−0.0610

$$\lim_{x \to 3} \frac{[1/(x+1)]-(1/4)}{x-3} \approx -0.0625 \left(\text{Actual limit is } -\frac{1}{16}.\right)$$

7.

x	−0.1	−0.01	−0.001
$f(x)$	0.9983	0.99998	1.0000

x	0.001	0.01	0.1
$f(x)$	1.0000	0.99998	0.9983

$$\lim_{x \to 0} \frac{\sin x}{x} \approx 1.0000 \text{ (Actual limit is 1.)}$$

9.

x	0.9	0.99	0.999	1.001	1.01	1.1
$f(x)$	0.2564	0.2506	0.2501	0.2499	0.2494	0.2439

$$\lim_{x \to 1} \frac{x-2}{x^2+x-6} \approx 0.2500 \left(\text{Actual limit is } \frac{1}{4}.\right)$$

11.

x	0.9	0.99	0.999	1.001	1.01	1.1
$f(x)$	0.7340	0.6733	0.6673	0.6660	0.6600	0.6015

$$\lim_{x \to 1} \frac{x^4-1}{x^6-1} \approx 0.6666 \left(\text{Actual limit is } \frac{2}{3}.\right)$$

13.

x	−0.1	−0.01	−0.001	0.001	0.01	0.1
$f(x)$	1.9867	1.9999	2.0000	2.0000	1.9999	1.9867

$$\lim_{x \to 0} \frac{\sin 2x}{x} \approx 2.0000 \text{ (Actual limit is 2.)}$$

15. 1 **17.** 2

19. Limit does not exist. The function approaches 1 from the right side of 2 but it approaches −1 from the left side of 2.

21. 0

23. Limit does not exist. The function oscillates between 1 and −1 as x approaches 0.

25. (a) 2

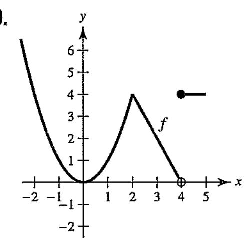
(b) Limit does not exist. The function approaches 1 from the right side of 1 but it approaches 3.5 from the left side of 1.

(c) Value does not exist. The function is undefined at $x = 4$.

(d) 2

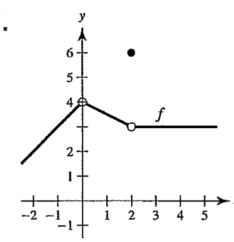
27. $\lim_{x \to c} f(x)$ exists for all points on the graph except where $c = -3$.

29.

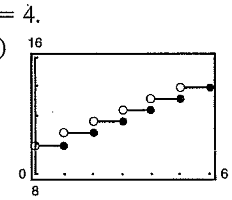


$\lim_{x \to c} f(x)$ exists for all points on the graph except where $c = 4$.

31.



33. (a)



(b)

t	3	3.3	3.4	3.5	3.6	3.7	4
C	11.57	12.36	12.36	12.36	12.36	12.36	12.36

$\lim_{t\to3.5} C(t) = 12.36$

(c)

t	2	2.5	2.9	3	3.1	3.5	4
C	10.78	11.57	11.57	11.57	12.36	12.36	12.36

The limit does not exist because the limits from the right and left are not equal.

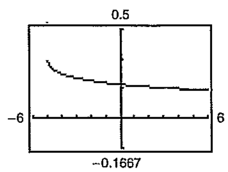
35. $\delta = 0.4$ **37.** $\delta = \frac{1}{11} \approx 0.091$

39. $L = 8$. Let $\delta = 0.01/3 \approx 0.0033$.

41. $L = 1$. Let $\delta = 0.01/5 = 0.002$.

43. 6 **45.** -3 **47.** 3 **49.** 0 **51.** 10 **53.** 2 **55.** 4

57.

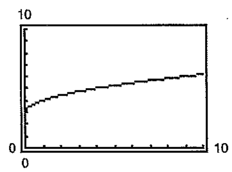


$\lim_{x\to4} f(x) = \frac{1}{6}$

Domain: $[-5, 4) \cup (4, \infty)$

The graph has a hole at $x = 4$.

59.



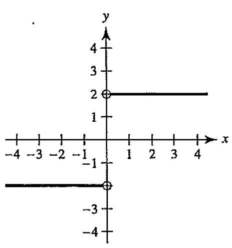
$\lim_{x\to9} f(x) = 6$

Domain: $[0, 9) \cup (9, \infty)$

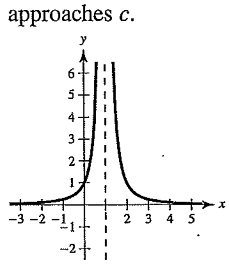
The graph has a hole at $x = 9$.

61. Answers will vary. Sample answer: As x approaches 8 from either side, $f(x)$ becomes arbitrarily close to 25.

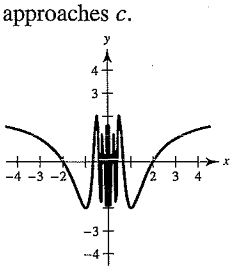
63. (i) The values of f approach different numbers as x approaches c from different sides of c.



(ii) The values of f increase or decrease without bound as x approaches c.



(iii) The values of f oscillate between two fixed numbers as x approaches c.



65. (a) $r = \frac{3}{\pi} \approx 0.9549$ cm

(b) $\frac{5.5}{2\pi} \le r \le \frac{6.5}{2\pi}$, or approximately $0.8754 < r < 1.0345$

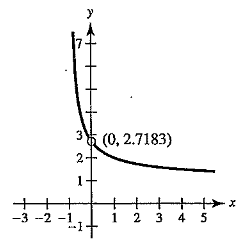
(c) $\lim_{r\to3/\pi} 2\pi r = 6$; $\varepsilon = 0.5$; $\delta \approx 0.0796$

67.

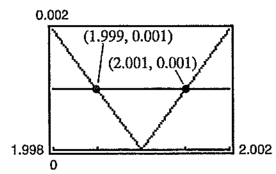
x	-0.001	-0.0001	-0.00001
$f(x)$	2.7196	2.7184	2.7183

x	0.00001	0.0001	0.001
$f(x)$	2.7183	2.7181	2.7169

$\lim_{x\to0} f(x) \approx 2.7183$



69.



$\delta = 0.001$

$(1.999, 2.001)$

71. False. The existence or nonexistence of $f(x)$ at $x = c$ has no bearing on the existence of the limit of $f(x)$ as $x \to c$.

73. False. See Exercise 17.

75. Yes. As x approaches 0.25 from either side, $\sqrt{x}$ becomes arbitrarily close to 0.5.

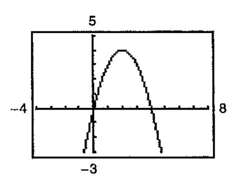
77. $\lim_{x\to0} \frac{\sin nx}{x} = n$

79–81. Proofs **83.** Answers will vary.

85. Putnam Problem B1, 1986

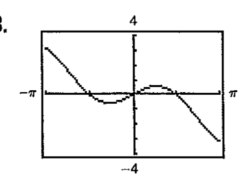
Section 1.3 (page 67)

1.



(a) 0 (b) -5

3.



(a) 0 (b) About 0.52 or $\pi/6$

5. 8 **7.** -1 **9.** 0 **11.** 7 **13.** 2 **15.** 1

17. 1/2 **19.** 1/5 **21.** 7 **23.** (a) 4 (b) 64 (c) 64

25. (a) 3 (b) 2 (c) 2 **27.** 1 **29.** 1/2 **31.** 1

33. 1/2 **35.** -1 **37.** (a) 10 (b) 5 (c) 6 (d) 3/2

39. (a) 64 (b) 2 (c) 12 (d) 8

41. (a) -1 (b) -2

$g(x) = \frac{x^2 - x}{x}$ and $f(x) = x - 1$ agree except at $x = 0$.

43. (a) 2 (b) 0

$g(x) = \dfrac{x^3 - x}{x - 1}$ and $f(x) = x^2 + x$ agree except at $x = 1$.

45. -2

$f(x) = \dfrac{x^2 - 1}{x + 1}$ and $g(x) = x - 1$ agree except at $x = -1$.

47. 12

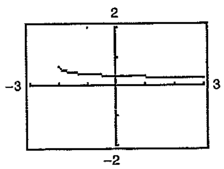
$f(x) = \dfrac{x^3 - 8}{x - 2}$ and $g(x) = x^2 + 2x + 4$ agree except at $x = 2$.

49. -1 **51.** $1/8$ **53.** $5/6$ **55.** $1/6$ **57.** $\sqrt{5}/10$

59. $-1/9$ **61.** 2 **63.** $2x - 2$

65. $1/5$ **67.** 0 **69.** 0 **71.** 0 **73.** 1 **75.** $3/2$

77.



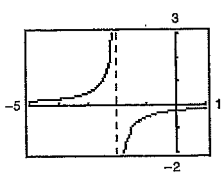
The graph has a hole at $x = 0$.

Answers will vary. Example:

x	-0.1	-0.01	-0.001	0.001	0.01	0.1
$f(x)$	0.358	0.354	0.354	0.354	0.353	0.349

$\lim_{x\to 0} \dfrac{\sqrt{x+2} - \sqrt{2}}{x} \approx 0.354 \left(\text{Actual limit is } \dfrac{1}{2\sqrt{2}} = \dfrac{\sqrt{2}}{4}.\right)$

79.



The graph has a hole at $x = 0$.

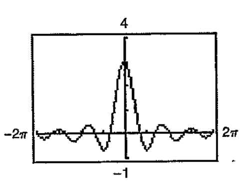
Answers will vary. Example:

x	-0.1	-0.01	-0.001
$f(x)$	-0.263	-0.251	-0.250

x	0.001	0.01	0.1
$f(x)$	-0.250	-0.249	-0.238

$\lim_{x\to 0} \dfrac{[1/(2+x)] - (1/2)}{x} \approx -0.250 \left(\text{Actual limit is } -\dfrac{1}{4}.\right)$

81.



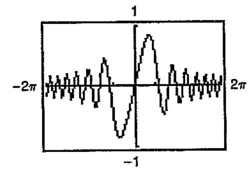
The graph has a hole at $t = 0$.

Answers will vary. Example:

t	-0.1	-0.01	0	0.01	0.1
$f(t)$	2.96	2.9996	?	2.9996	2.96

$\lim_{t\to 0} \dfrac{\sin 3t}{t} = 3$

83.



The graph has a hole at $x = 0$.

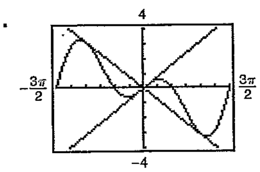
Answers will vary. Example:

x	-0.1	-0.01	-0.001	0	0.001	0.01	0.1
$f(x)$	-0.1	-0.01	-0.001	?	0.001	0.01	0.1

$\lim_{x\to 0} \dfrac{\sin x^2}{x} = 0$

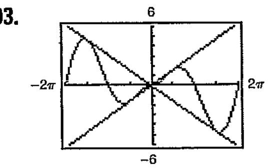
85. 3 **87.** $-1/(x+3)^2$ **89.** 4

91.



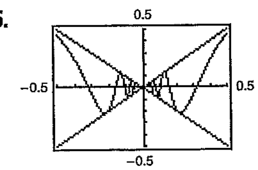
0

93.



0

95.



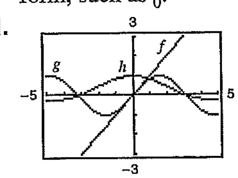
0

The graph has a hole at $x = 0$.

97. f and g agree at all but one point if c is a real number such that $f(x) = g(x)$ for all $x \neq c$.

99. An indeterminate form is obtained when evaluating a limit using direct substitution produces a meaningless fractional form, such as $\frac{0}{0}$.

101.



The magnitudes of $f(x)$ and $g(x)$ are approximately equal when x is close to 0. Therefore, their ratio is approximately 1.

103. -64 ft/sec (speed $= 64$ ft/sec) **105.** -29.4 m/sec

107. Let $f(x) = 1/x$ and $g(x) = -1/x$.

$\lim_{x\to 0} f(x)$ and $\lim_{x\to 0} g(x)$ do not exist. However,

$\lim_{x\to 0} [f(x) + g(x)] = \lim_{x\to 0} \left[\dfrac{1}{x} + \left(-\dfrac{1}{x}\right)\right] = \lim_{x\to 0} 0 = 0$

and therefore does exist.

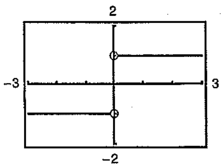
109–113. Proofs

115. Let $f(x) = \begin{cases} 4, & \text{if } x \geq 0 \\ -4, & \text{if } x < 0 \end{cases}$

$\lim_{x\to 0} |f(x)| = \lim_{x\to 0} 4 = 4$

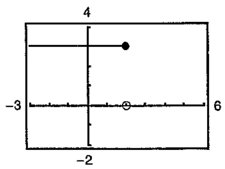
$\lim_{x\to 0} f(x)$ does not exist because for $x < 0$, $f(x) = -4$ and for $x \geq 0$, $f(x) = 4$.

117. False. The limit does not exist because the function approaches 1 from the right side of 0 and approaches -1 from the left side of 0. (See graph below.)



119. True.

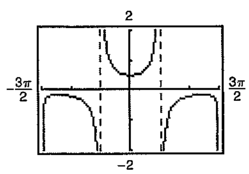
121. False. The limit does not exist because $f(x)$ approaches 3 from the left side of 2 and approaches 0 from the right side of 2. (See graph below.)



123. Proof

125. (a) All $x \neq 0, \dfrac{\pi}{2} + n\pi$

(b)



The domain is not obvious. The hole at $x = 0$ is not apparent from the graph.

(c) $\dfrac{1}{2}$ (d) $\dfrac{1}{2}$

127. The graphing utility was not set in *radian* mode.

Section 1.4 (page 78)

1. (a) 3 (b) 3 (c) 3; $f(x)$ is continuous on $(-\infty, \infty)$.

3. (a) 0 (b) 0 (c) 0; Discontinuity at $x = 3$

5. (a) -3 (b) 3 (c) Limit does not exist.
Discontinuity at $x = 2$

7. $\frac{1}{16}$ **9.** $\frac{1}{10}$

11. Limit does not exist. The function decreases without bound as x approaches -3 from the left.

13. -1 **15.** $-1/x^2$ **17.** $5/2$ **19.** 2

21. Limit does not exist. The function decreases without bound as x approaches π from the left and increases without bound as x approaches π from the right.

23. 8

25. Limit does not exist. The function approaches 5 from the left side of 3 but approaches 6 from the right side of 3.

27. Discontinuous at $x = -2$ and $x = 2$

29. Discontinuous at every integer

31. Continuous on $[-7, 7]$ **33.** Continuous on $[-1, 4]$

35. Nonremovable discontinuity at $x = 0$

37. Continuous for all real x

39. Nonremovable discontinuities at $x = -2$ and $x = 2$

41. Continuous for all real x

43. Nonremovable discontinuity at $x = 1$
Removable discontinuity at $x = 0$

45. Continuous for all real x

47. Removable discontinuity at $x = -2$
Nonremovable discontinuity at $x = 5$

49. Nonremovable discontinuity at $x = -7$

51. Continuous for all real x

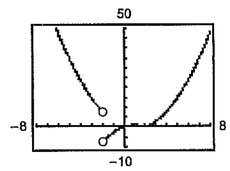
53. Nonremovable discontinuity at $x = 2$

55. Continuous for all real x

57. Nonremovable discontinuities at integer multiples of $\pi/2$

59. Nonremovable discontinuities at each integer

61.



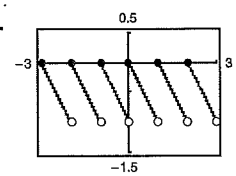
$\lim_{x\to 0^+} f(x) = 0$
$\lim_{x\to 0^-} f(x) = 0$
Discontinuity at $x = -2$

63. $a = 7$ **65.** $a = 2$ **67.** $a = -1, b = 1$

69. Continuous for all real x

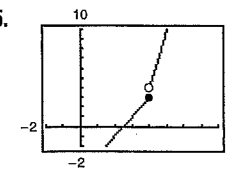
71. Nonremovable discontinuities at $x = 1$ and $x = -1$

73.



Nonremovable discontinuity at each integer

75.

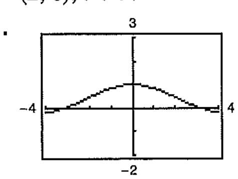


Nonremovable discontinuity at $x = 4$

77. Continuous on $(-\infty, \infty)$

79. Continuous on the open intervals $\ldots (-6, -2), (-2, 2), (2, 6), \ldots$

81.



The graph has a hole at $x = 0$. The graph appears to be continuous, but the function is not continuous on $[-4, 4]$. It is not obvious from the graph that the function has a discontinuity at $x = 0$.

83. Because $f(x)$ is continuous on the interval $[1, 2]$ and $f(1) = 37/12$ and $f(2) = -8/3$, by the Intermediate Value Theorem there exists a real number c in $[1, 2]$ such that $f(c) = 0$.

85. Because $f(x)$ is continuous on the interval $[0, \pi]$ and $f(0) = -3$ and $f(\pi) \approx 8.87$, by the Intermediate Value Theorem there exists a real number c in $[0, \pi]$ such that $f(c) = 0$.

87. 0.68, 0.6823 **89.** 0.56, 0.5636

91. $f(3) = 11$ **93.** $f(2) = 4$

95. (a) The limit does not exist at $x = c$.
(b) The function is not defined at $x = c$.
(c) The limit exists, but it is not equal to the value of the function at $x = c$.
(d) The limit does not exist at $x = c$.

97. If f and g are continuous for all real x, then so is $f + g$ (Theorem 1.11, part 2). However, f/g might not be continuous if $g(x) = 0$. For example, let $f(x) = x$ and $g(x) = x^2 - 1$. Then f and g are continuous for all real x, but f/g is not continuous at $x = \pm 1$.

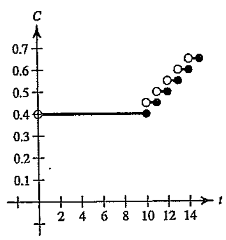
99. True

101. False. A rational function can be written as $P(x)/Q(x)$ where P and Q are polynomials of degree m and n, respectively. It can have, at most, n discontinuities.

103. $\lim_{t\to 4^-} f(t) \approx 28$; $\lim_{t\to 4^+} f(t) \approx 56$

At the end of day 3, the amount of chlorine in the pool is about 28 oz. At the beginning of day 4, the amount of chlorine in the pool is about 56 oz.

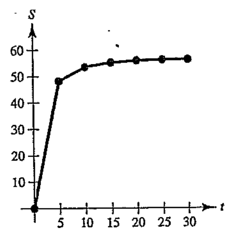
105. $C = \begin{cases} 0.40, & 0 < t \le 10 \\ 0.40 + 0.05[\![t - 9]\!], & t > 10, t \text{ is not an integer} \\ 0.40 + 0.05(t - 10), & t > 10, t \text{ is an integer} \end{cases}$



There is a nonremovable discontinuity at each integer greater than or equal to 10.

107–109. Proofs **111.** Answers will vary.

113. (a)

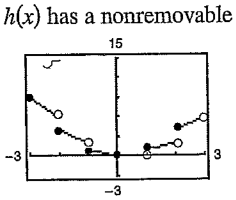


(b) There appears to be a limiting speed, and a possible cause is air resistance.

115. $c = (-1 \pm \sqrt{5})/2$

117. Domain: $[-c^2, 0) \cup (0, \infty)$; Let $f(0) = 1/(2c)$

119. $h(x)$ has a nonremovable discontinuity at every integer except 0.



121. Putnam Problem B2, 1988

Section 1.5 (page 88)

1. $\lim_{x\to 4^+} \frac{1}{x-4} = \infty$, $\lim_{x\to 4^-} \frac{1}{x-4} = -\infty$

3. $\lim_{x\to 4^+} \frac{1}{(x-4)^2} = \infty$, $\lim_{x\to 4^-} \frac{1}{(x-4)^2} = \infty$

5. $\lim_{x\to -2^+} 2\left|\frac{x}{x^2-4}\right| = \infty$, $\lim_{x\to -2^-} 2\left|\frac{x}{x^2-4}\right| = \infty$

7. $\lim_{x\to -2^+} \tan(\pi x/4) = -\infty$, $\lim_{x\to -2^-} \tan(\pi x/4) = \infty$

9.

x	-3.5	-3.1	-3.01	-3.001
$f(x)$	0.31	1.64	16.6	167

x	-2.999	-2.99	-2.9	-2.5
$f(x)$	-167	-16.7	-1.69	-0.36

$\lim_{x\to -3^+} f(x) = -\infty$ $\lim_{x\to -3^-} f(x) = \infty$

11.

x	-3.5	-3.1	-3.01	-3.001
$f(x)$	3.8	16	151	1501

x	-2.999	-2.99	-2.9	-2.5
$f(x)$	-1499	-149	-14	-2.3

$\lim_{x\to -3^+} f(x) = -\infty$ $\lim_{x\to -3^-} f(x) = \infty$

13. $x = 0$ **15.** $x = \pm 2$ **17.** No vertical asymptote

19. $x = 2$, $x = -1$ **21.** $t = 0$ **23.** $x = -2, x = 1$

25. No vertical asymptote **27.** No vertical asymptote

29. $x = \frac{1}{2} + n$, n is an integer.

31. $t = n\pi$, n is a nonzero integer.

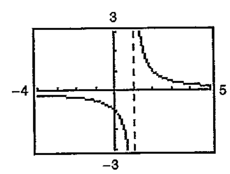
33. Removable discontinuity at $x = -1$

35. Vertical asymptote at $x = -1$ **37.** ∞ **39.** ∞

41. ∞ **43.** $-\frac{1}{5}$ **45.** $\frac{1}{2}$ **47.** $-\infty$ **49.** ∞ **51.** 0

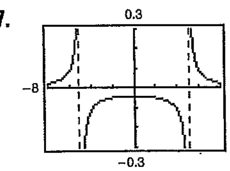
53. Limit does not exist.

55.



$\lim_{x\to 1^+} f(x) = \infty$

57.

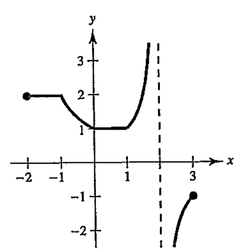


$\lim_{x\to 5^-} f(x) = -\infty$

59. Answers will vary.

61. Answers will vary. Example: $f(x) = \frac{x-3}{x^2 - 4x - 12}$

63.



65. ∞

67. (a) $\frac{1}{3}(200\pi)$ ft/sec

(b) 200π ft/sec

(c) $\lim_{\theta\to(\pi/2)^-} [50\pi \sec^2 \theta] = \infty$

69. (a) Domain: $x > 25$

(b)

x	30	40	50	60
y	150	66.667	50	42.857

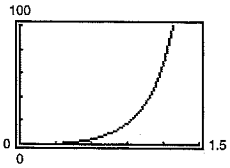
(c) $\lim_{x\to 25^+} \frac{25x}{x-25} = \infty$

As x gets closer and closer to 25 mi/h, y becomes larger and larger.

71. (a) $A = 50 \tan\theta - 50\theta$; Domain: $(0, \pi/2)$

(b)

θ	0.3	0.6	0.9	1.2	1.5
$f(\theta)$	0.47	4.21	18.0	68.6	630.1



(c) $\lim_{\theta\to\pi/2^-} A = \infty$

73. False; let $f(x) = (x^2 - 1)/(x - 1)$

75. False; let $f(x) = \tan x$

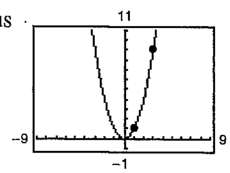
77. Let $f(x) = \dfrac{1}{x^2}$ and $g(x) = \dfrac{1}{x^4}$, and let $c = 0$. $\lim_{x\to 0} \dfrac{1}{x^2} = \infty$ and $\lim_{x\to 0} \dfrac{1}{x^4} = \infty$, but $\lim_{x\to 0}\left(\dfrac{1}{x^2} - \dfrac{1}{x^4}\right) = \lim_{x\to 0}\left(\dfrac{x^2 - 1}{x^4}\right) = -\infty \neq 0$.

79. Given $\lim_{x\to c} f(x) = \infty$, let $g(x) = 1$. Then $\lim_{x\to c} \dfrac{g(x)}{f(x)} = 0$ by Theorem 1.15.

81. Answers will vary.

Review Exercises for Chapter 1 (page 91)

1. Calculus



Estimate: 8.3

3.

x	−0.1	−0.01	−0.001
$f(x)$	−1.0526	−1.0050	−1.0005

x	0.001	0.01	0.1
$f(x)$	−0.9995	−0.9950	−0.9524

The estimate of the limit of $f(x)$, as x approaches zero, is -1.00.

5. 5; Proof **7.** −3; Proof **9.** (a) 4 (b) 5 **11.** 16
13. $\sqrt{6} \approx 2.45$ **15.** $-\frac{1}{4}$ **17.** $\frac{1}{2}$ **19.** −1 **21.** 75
23. 0 **25.** $\sqrt{3}/2$ **27.** $-\frac{1}{2}$ **29.** $\frac{7}{12}$

31. (a)

x	1.1	1.01	1.001	1.0001
$f(x)$	0.5680	0.5764	0.5773	0.5773

$\lim_{x\to 1^+} f(x) \approx 0.5773$

(b)

The graph has a hole at $x = 1$.
$\lim_{x\to 1^+} f(x) \approx 0.5774$

(c) $\sqrt{3}/3$

33. −39.2 m/sec **35.** −1 **37.** 0

39. Limit does not exist. The limit as t approaches 1 from the left is 2 whereas the limit as t approaches 1 from the right is 1.

41. Continuous for all real x

43. Nonremovable discontinuity at each integer
Continuous on $(k, k + 1)$ for all integers k

45. Removable discontinuity at $x = 1$
Continuous on $(-\infty, 1) \cup (1, \infty)$

47. Nonremovable discontinuity at $x = 2$
Continuous on $(-\infty, 2) \cup (2, \infty)$

49. Nonremovable discontinuity at $x = -1$
Continuous on $(-\infty, -1) \cup (-1, \infty)$

51. Nonremovable discontinuity at each even integer
Continuous on $(2k, 2k + 2)$ for all integers k

53. $c = -\frac{1}{2}$ **55.** Proof

57. (a) −4 (b) 4 (c) Limit does not exist.

59. $x = 0$ **61.** $x = 10$ **63.** $-\infty$ **65.** $\frac{1}{3}$

67. $-\infty$ **69.** $-\infty$ **71.** $\frac{4}{5}$ **73.** ∞

75. (a) \$14,117.65 (b) \$80,000.00 (c) \$720,000.00 (d) ∞

P.S. Problem Solving (page 93)

1. (a) Perimeter $\triangle PAO = 1 + \sqrt{(x^2 - 1)^2 + x^2} + \sqrt{x^4 + x^2}$
Perimeter $\triangle PBO = 1 + \sqrt{x^4 + (x - 1)^2} + \sqrt{x^4 + x^2}$

(b)

x	4	2	1
Perimeter $\triangle PAO$	33.0166	9.0777	3.4142
Perimeter $\triangle PBO$	33.7712	9.5952	3.4142
$r(x)$	0.9777	0.9461	1.0000

x	0.1	0.01
Perimeter $\triangle PAO$	2.0955	2.0100
Perimeter $\triangle PBO$	2.0006	2.0000
$r(x)$	1.0475	1.0050

(c) 1

3. (a) Area (hexagon) $= (3\sqrt{3})/2 \approx 2.5981$
Area (circle) $= \pi \approx 3.1416$
Area (circle) − Area (hexagon) ≈ 0.5435

(b) $A_n = (n/2)\sin(2\pi/n)$

(c)

n	6	12	24	48	96
A_n	2.5981	3.0000	3.1058	3.1326	3.1394

(d) 3.1416 or π

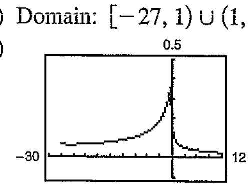
5. (a) $m = -\frac{12}{5}$ (b) $y = \frac{5}{12}x - \frac{169}{12}$

(c) $m_x = \dfrac{-\sqrt{169 - x^2} + 12}{x - 5}$

(d) $\frac{5}{12}$; It is the same as the slope of the tangent line found in (b).

7. (a) Domain: $[-27, 1) \cup (1, \infty)$

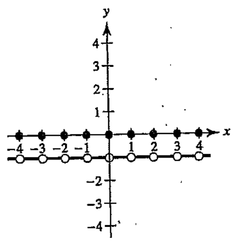
(b)



The graph has a hole at $x = 1$.

(c) $\frac{1}{14}$ (d) $\frac{1}{12}$

9. (a) g_1, g_4 (b) g_1 (c) g_1, g_3, g_4

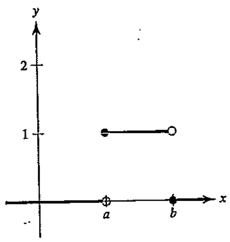
11. 

The graph jumps at every integer.

(a) $f(1) = 0,\ f(0) = 0,\ f(\frac{1}{2}) = -1,\ f(-2.7) = -1$

(b) $\lim_{x \to 1^-} f(x) = -1,\ \lim_{x \to 1^+} f(x) = -1,\ \lim_{x \to 1/2} f(x) = -1$

(c) There is a discontinuity at each integer.

13. (a) 

(b) (i) $\lim_{x \to a^+} P_{a,b}(x) = 1$

(ii) $\lim_{x \to a^-} P_{a,b}(x) = 0$

(iii) $\lim_{x \to b^+} P_{a,b}(x) = 0$

(iv) $\lim_{x \to b^-} P_{a,b}(x) = 1$

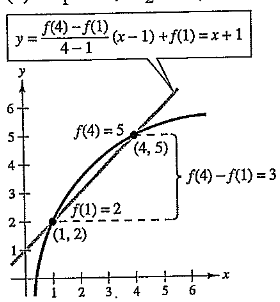
(c) Continuous for all positive real numbers except a and b

(d) The area under the graph of U and above the x-axis is 1.

Chapter 2

Section 2.1 (page 103)

1. (a) $m_1 = 0, m_2 = 5/2$ (b) $m_1 = -5/2, m_2 = 2$

3. 

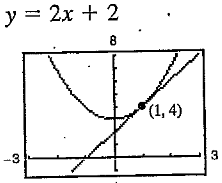
5. $m = -5$ **7.** $m = 4$

9. $m = 3$ **11.** $f'(x) = 0$ **13.** $f'(x) = -10$ **15.** $h'(s) = \frac{2}{3}$

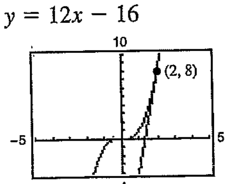
17. $f'(x) = 2x + 1$ **19.** $f'(x) = 3x^2 - 12$

21. $f'(x) = \dfrac{-1}{(x-1)^2}$ **23.** $f'(x) = \dfrac{1}{2\sqrt{x+4}}$

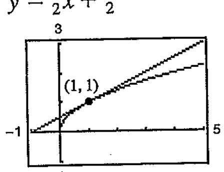
25. (a) Tangent line: $y = 2x + 2$

(b) 

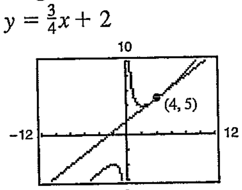
27. (a) Tangent line: $y = 12x - 16$

(b) 

29. (a) Tangent line: $y = \frac{1}{2}x + \frac{1}{2}$

(b) 

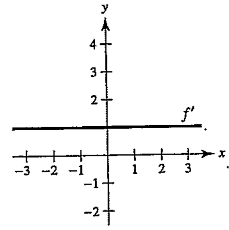
31. (a) Tangent line: $y = \frac{3}{4}x + 2$

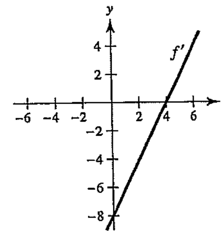
(b) 

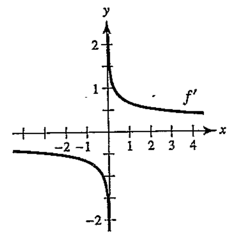
33. $y = 2x - 1$ **35.** $y = 3x - 2; y = 3x + 2$

37. $y = -\frac{1}{2}x + \frac{3}{2}$ **39.** b **40.** d **41.** a **42.** c

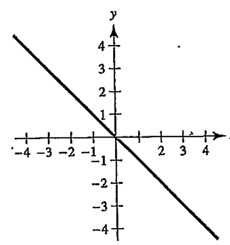
43. $g(4) = 5; g'(4) = -\frac{5}{3}$

45. 

47. 

49. 

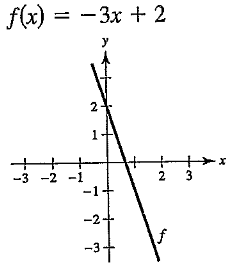
51. Answers will vary.
Sample answer: $y = -x$



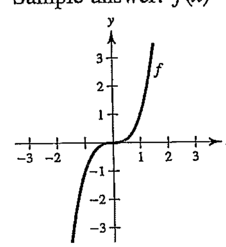
53. $f(x) = 5 - 3x$
$c = 1$

55. $f(x) = -x^2$
$c = 6$

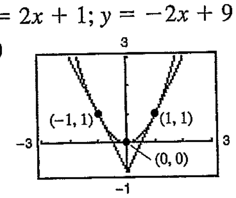
57. $f(x) = -3x + 2$



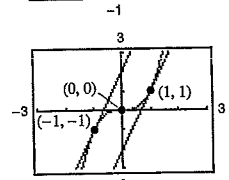
59. Answers will vary.
Sample answer: $f(x) = x^3$



61. $y = 2x + 1; y = -2x + 9$

63. (a) 

For this function, the slopes of the tangent lines are always distinct for different values of x.

(b) 

For this function, the slopes of the tangent lines are sometimes the same.