

A

Selected Answers

- 1.1.1. $(2/3)x + (1/3)$
- 1.1.2. $y = -2x$
- 1.1.3. $(-2/3)x + (1/3)$
- 1.1.4. $y = 2x + 2, 2, -1$
- 1.1.5. $y = -x + 6, 6, 6$
- 1.1.6. $y = x/2 + 1/2, 1/2, -1$
- 1.1.7. $y = 3/2$, y -intercept: $3/2$, no x -intercept
- 1.1.8. $y = (-2/3)x - 2, -2, -3$
- 1.1.9. yes
- 1.1.10. $y = 0, y = -2x + 2, y = 2x + 2$
- 1.1.11. $y = 75t$ (t in hours); 164 minutes
- 1.1.12. $y = (9/5)x + 32, (-40, -40)$
- 1.1.13. $y = 0.15x + 10$
- 1.1.14. $0.03x + 1.2$
- 1.1.15. (a) $y = \begin{cases} 0 & 0 \leq x < 100 \\ (x/10) - 10 & 100 \leq x \leq 1000 \\ x - 910 & 1000 < x \end{cases}$
- 1.1.16. $y = \begin{cases} 0.15x & 0 \leq x \leq 19450 \\ 0.28x - 2528.50 & 19450 < x \leq 47050 \\ 0.33x - 4881 & 47050 < x \leq 97620 \end{cases}$
- 1.1.17. (a) $P = -0.0001x + 2$
(b) $x = -10000P + 20000$
- 1.1.18. $(2/25)x - (16/5)$
- 1.2.1. (a) $x^2 + y^2 = 9$
(b) $(x - 5)^2 + (y - 6)^2 = 9$
(c) $(x + 5)^2 + (y + 6)^2 = 9$
(d) $x^2 + (y - 3)^2 = 9$
(e) $x^2 + (y + 3)^2 = 9$
(f) $(x - 3)^2 + y^2 = 9$
- 1.2.2. (a) $\Delta x = 2, \Delta y = 3, m = 3/2,$
 $y = (3/2)x - 3, \sqrt{13}$
(b) $\Delta x = -1, \Delta y = 3, m = -3,$
 $y = -3x + 2, \sqrt{10}$
(c) $\Delta x = -2, \Delta y = -2, m = 1,$
 $y = x, \sqrt{8}$
- 1.2.6. $(x + 2/7)^2 + (y - 41/7)^2 = 1300/49$
- 1.3.1. $\{x \mid x \geq 3/2\}$
- 1.3.2. $\{x \mid x \neq -1\}$

- 1.3.3.** $\{x \mid x \neq 1 \text{ and } x \neq -1\}$
1.3.4. $\{x \mid x < 0\}$
1.3.5. $\{x \mid x \in \mathbb{R}\}$, i.e., all x
1.3.6. $\{x \mid x \geq 0\}$
1.3.7. $\{x \mid h - r \leq x \leq h + r\}$
1.3.8. $\{x \mid x \geq 1 \text{ or } x < 0\}$
1.3.9. $\{x \mid -1/3 < x < 1/3\}$
1.3.10. $\{x \mid x \geq 0 \text{ and } x \neq 1\}$
1.3.11. $\{x \mid x \geq 0 \text{ and } x \neq 1\}$
1.3.12. \mathbb{R}
1.3.13. $\{x \mid x \geq 3\}$, $\{x \mid x \geq 0\}$
1.3.14. $A = x(500 - 2x)$, $\{x \mid 0 \leq x \leq 250\}$
1.3.15. $V = r(50 - \pi r^2)$, $\{r \mid 0 < r \leq \sqrt{50/\pi}\}$
1.3.16. $A = 2\pi r^2 + 2000/r$, $\{r \mid 0 < r < \infty\}$
2.1.1. -5 , -2.47106145 , -2.4067927 ,
 -2.400676 , -2.4
2.1.2. $-4/3$, $-24/7$, $7/24$, $3/4$
2.1.3. -0.107526881 , -0.11074197 ,
 -0.1110741 , $\frac{-1}{3(3 + \Delta x)} \rightarrow \frac{-1}{9}$
2.1.4. $\frac{3 + 3\Delta x + \Delta x^2}{1 + \Delta x} \rightarrow 3$
2.1.5. 3.31 , 3.003001 , 3.0000 ,
 $3 + 3\Delta x + \Delta x^2 \rightarrow 3$
2.1.6. m
2.2.1. 10 , $25/2$, 20 , 15 , 25 , 35 .
2.2.2. 5 , 4.1 , 4.01 , 4.001 , $4 + \Delta t \rightarrow 4$
2.2.3. -10.29 , -9.849 , -9.8049 ,
 $-9.8 - 4.9\Delta t \rightarrow -9.8$
2.3.1. 7
2.3.2. 5
2.3.3. 0
2.3.4. undefined
2.3.5. $1/6$
2.3.6. 0
2.3.7. 3
2.3.8. 172
2.3.9. 0
2.3.10. 2
2.3.11. does not exist
2.3.12. $\sqrt{2}$
2.3.13. $3a^2$
2.3.14. 512
2.3.15. -4
2.3.16. 0
2.3.18. (a) 8 , (b) 6 , (c) dne, (d) -2 , (e) -1 ,
(f) 8 , (g) 7 , (h) 6 , (i) 3 , (j) $-3/2$,
(k) 6 , (l) 2
2.4.1. $-x/\sqrt{169 - x^2}$
2.4.2. $-9.8t$
2.4.3. $2x + 1/x^2$
2.4.4. $2ax + b$
2.4.5. $3x^2$
2.4.8. $-2/(2x + 1)^{3/2}$
2.4.9. $5/(t + 2)^2$
2.4.10. $y = -13x + 17$
2.4.11. -8
2.5.2. Yes; $M = 1$
2.5.3. Yes; $M = 1$
2.5.4. No
2.5.5. No
2.5.6. -0.5 or 1.3 or 3.2
2.5.7. 0.2 or 1.3
3.1.1. $100x^{99}$

- 3.1.2.** $-100x^{-101}$
3.1.3. $-5x^{-6}$
3.1.4. $\pi x^{\pi-1}$
3.1.5. $(3/4)x^{-1/4}$
3.1.6. $-(9/7)x^{-16/7}$
3.2.1. $15x^2 + 24x$
3.2.2. $-20x^4 + 6x + 10/x^3$
3.2.3. $-30x + 25$
3.2.4. $6x^2 + 2x - 8$
3.2.5. $3x^2 + 6x - 1$
3.2.6. $9x^2 - x/\sqrt{625 - x^2}$
3.2.7. $y = 13x/4 + 5$
3.2.8. $y = 24x - 48 - \pi^3$
3.2.9. $-49t/5 + 5, -49/5$
3.2.11. $\sum_{k=1}^n ka_k x^{k-1}$
3.2.12. $x^3/16 - 3x/4 + 4$
3.3.1. $3x^2(x^3 - 5x + 10) + x^3(3x^2 - 5)$
3.3.2. $(x^2 + 5x - 3)(5x^4 - 18x^2 + 6x - 7) + (2x + 5)(x^5 - 6x^3 + 3x^2 - 7x + 1)$
3.3.3. $\frac{\sqrt{625 - x^2}}{2\sqrt{x}} - \frac{x\sqrt{x}}{\sqrt{625 - x^2}}$
3.3.4. $\frac{-1}{x^{19}\sqrt{625 - x^2}} - \frac{20\sqrt{625 - x^2}}{x^{21}}$
3.3.5. $f' = 4(2x - 3), y = 4x - 7$
3.4.1. $\frac{3x^2}{x^3 - 5x + 10} - \frac{x^3(3x^2 - 5)}{(x^3 - 5x + 10)^2}$
3.4.2. $\frac{2x + 5}{x^5 - 6x^3 + 3x^2 - 7x + 1} - \frac{(x^2 + 5x - 3)(5x^4 - 18x^2 + 6x - 7)}{(x^5 - 6x^3 + 3x^2 - 7x + 1)^2}$
3.4.3. $\frac{1}{2\sqrt{x}\sqrt{625 - x^2}} + \frac{x^{3/2}}{(625 - x^2)^{3/2}}$
3.4.4. $\frac{-1}{x^{19}\sqrt{625 - x^2}} - \frac{20\sqrt{625 - x^2}}{x^{21}}$
3.4.5. $y = 17x/4 - 41/4$
3.4.6. $y = 11x/16 - 15/16$
3.4.8. $y = 19/169 - 5x/338$
3.4.9. $13/18$
3.5.1. $4x^3 - 9x^2 + x + 7$
3.5.2. $3x^2 - 4x + 2/\sqrt{x}$
3.5.3. $6(x^2 + 1)^2x$
3.5.4. $\sqrt{169 - x^2} - x^2/\sqrt{169 - x^2}$
3.5.5. $(2x - 4)\sqrt{25 - x^2} - (x^2 - 4x + 5)x/\sqrt{25 - x^2}$
3.5.6. $-x/\sqrt{r^2 - x^2}$
3.5.7. $2x^3/\sqrt{1 + x^4}$
3.5.8. $\frac{1}{4\sqrt{x}(5 - \sqrt{x})^{3/2}}$
3.5.9. $6 + 18x$
3.5.10. $\frac{2x + 1}{1 - x} + \frac{x^2 + x + 1}{(1 - x)^2}$
3.5.11. $-1/\sqrt{25 - x^2} - \sqrt{25 - x^2}/x^2$
3.5.12. $\frac{1}{2} \left(\frac{-169}{x^2} - 1 \right) / \sqrt{\frac{169}{x} - x}$
3.5.13. $\frac{3x^2 - 2x + 1/x^2}{2\sqrt{x^3 - x^2 - (1/x)}}$
3.5.14. $\frac{300x}{(100 - x^2)^{5/2}}$
3.5.15. $\frac{1 + 3x^2}{3(x + x^3)^{2/3}}$
3.5.16. $\left(4x(x^2 + 1) + \frac{4x^3 + 4x}{2\sqrt{1 + (x^2 + 1)^2}} \right) / 2\sqrt{(x^2 + 1)^2 + \sqrt{1 + (x^2 + 1)^2}}$
3.5.17. $5(x + 8)^4$
3.5.18. $-3(4 - x)^2$

- 3.5.19.** $6x(x^2 + 5)^2$
3.5.20. $-12x(6 - 2x^2)^2$
3.5.21. $24x^2(1 - 4x^3)^{-3}$
3.5.22. $5 + 5/x^2$
3.5.23. $-8(4x - 1)(2x^2 - x + 3)^{-3}$
3.5.24. $1/(x + 1)^2$
3.5.25. $3(8x - 2)/(4x^2 - 2x + 1)^2$
3.5.26. $-3x^2 + 5x - 1$
3.5.27. $6x(2x - 4)^3 + 6(3x^2 + 1)(2x - 4)^2$
3.5.28. $-2/(x - 1)^2$
3.5.29. $4x/(x^2 + 1)^2$
3.5.30. $(x^2 - 6x + 7)/(x - 3)^2$
3.5.31. $-5/(3x - 4)^2$
3.5.32. $60x^4 + 72x^3 + 18x^2 + 18x - 6$
3.5.33. $(5 - 4x)/((2x + 1)^2(x - 3)^2)$
3.5.34. $1/(2(2 + 3x)^2)$
3.5.35. $56x^6 + 72x^5 + 110x^4 + 100x^3 + 60x^2 + 28x + 6$
3.5.36. $y = 23x/96 - 29/96$
3.5.37. $y = 3 - 2x/3$
3.5.38. $y = 13x/2 - 23/2$
3.5.39. $y = 2x - 11$
3.5.40. $y = \frac{20 + 2\sqrt{5}}{5\sqrt{4 + \sqrt{5}}}x + \frac{3\sqrt{5}}{5\sqrt{4 + \sqrt{5}}}$
- 4.1.1.** $2n\pi - \pi/2$, any integer n
4.1.2. $n\pi \pm \pi/6$, any integer n
4.1.3. $(\sqrt{2} + \sqrt{6})/4$
4.1.4. $-(1 + \sqrt{3})/(1 - \sqrt{3}) = 2 + \sqrt{3}$
4.1.11. $t = \pi/2$
- 4.3.1.** 5
4.3.2. $7/2$
4.3.3. $3/4$
- 4.3.4.** 1
4.3.5. $-\sqrt{2}/2$
4.3.6. 7
4.3.7. 2
- 4.4.1.** $\sin(\sqrt{x}) \cos(\sqrt{x})/\sqrt{x}$
4.4.2. $\frac{\sin x}{2\sqrt{x}} + \sqrt{x} \cos x$
4.4.3. $-\frac{\cos x}{\sin^2 x}$
4.4.4. $\frac{(2x + 1) \sin x - (x^2 + x) \cos x}{\sin^2 x}$
4.4.5. $\frac{-\sin x \cos x}{\sqrt{1 - \sin^2 x}}$
- 4.5.1.** $\cos^2 x - \sin^2 x$
4.5.2. $-\sin x \cos(\cos x)$
4.5.3. $\frac{\tan x + x \sec^2 x}{2\sqrt{x} \tan x}$
4.5.4. $\frac{\sec^2 x(1 + \sin x) - \tan x \cos x}{(1 + \sin x)^2}$
4.5.5. $-\csc^2 x$
4.5.6. $-\csc x \cot x$
4.5.7. $3x^2 \sin(23x^2) + 46x^4 \cos(23x^2)$
4.5.8. 0
4.5.9. $-6 \cos(\cos(6x)) \sin(6x)$
4.5.10. $\frac{\sec \theta \tan \theta}{(1 + \sec \theta)^2} = \frac{\sin \theta}{(\cos \theta + 1)^2}$
4.5.11. $5t^4 \cos(6t) - 6t^5 \sin(6t)$
4.5.12. $3t^2(\sin(3t) + t \cos(3t))/\cos(2t) + 2t^3 \sin(3t) \sin(2t)/\cos^2(2t)$
4.5.13. $n\pi/2$, any integer n
4.5.14. $\pi/2 + n\pi$, any integer n
4.5.15. $y = \sqrt{3}x/2 + 3/4 - \sqrt{3}\pi/6$
4.5.16. $y = 8\sqrt{3}x + 4 - 8\sqrt{3}\pi/3$
4.5.17. $y = 3\sqrt{3}x/2 - \sqrt{3}\pi/4$

- 4.5.18.** $\pi/6 + 2n\pi, 5\pi/6 + 2n\pi$, any integer n
4.6.1. x/y
4.6.2. $-(2x + y)/(x + 2y)$
4.6.3. $(2xy - 3x^2 - y^2)/(2xy - 3y^2 - x^2)$
4.6.4. $\sin(x)\sin(y)/(\cos(x)\cos(y))$
4.6.5. $-\sqrt{y}/\sqrt{x}$
4.6.6. $(y \sec^2(x/y) - y^2)/(x \sec^2(x/y) + y^2)$
4.6.7. $(y - \cos(x + y))/(\cos(x + y) - x)$
4.6.8. $-y^2/x^2$
4.6.9. 1
4.6.12. $y = 2x \pm 6$
4.6.13. $y = x/2 \pm 3$
4.6.14. $(\sqrt{3}, 2\sqrt{3}), (-\sqrt{3}, -2\sqrt{3}),$
 $(2\sqrt{3}, \sqrt{3}), (-2\sqrt{3}, -\sqrt{3})$
4.6.15. $y = 7x/\sqrt{3} - 8/\sqrt{3}$
4.6.16. $y = (-y_1^{1/3}x + y_1^{1/3}x_1 + x_1^{1/3}y_1)/x_1^{1/3}$
4.6.17. $(y - y_1) = \frac{(x_1 - 2x_1^3 - 2x_1y_1^2)}{(y_1 + 2y_1^3 + 2y_1x_1^2)}(x - x_1)$
4.7.1. 1
4.7.2. $1/6$
4.7.3. $-\infty$
4.7.4. $1/16$
4.7.5. $1/3$
4.7.6. 0
4.7.7. $3/2$
4.7.8. $-1/4$
4.7.9. -3
4.7.10. $1/2$
4.7.11. 0
4.7.12. -1
4.7.13. $-1/2$
4.7.14. 5
4.7.15. ∞
4.7.16. ∞
4.7.17. $2/7$
4.7.18. 2
4.7.19. $-\infty$
4.7.20. 0
4.7.21. ∞
4.7.22. $1/2$
4.7.23. 0
4.7.24. $1/2$
4.7.25. 5
4.7.26. $2\sqrt{2}$
4.7.27. $-1/2$
4.7.28. 2
4.7.29. 0
4.7.30. ∞
4.7.31. 0
4.7.32. $3/2$
4.7.33. ∞
4.7.34. 5
4.7.35. $-1/2$
4.7.36. does not exist
4.7.37. ∞
4.7.38. $y = 1$ and $y = -1$
5.1.1. min at $x = 1/2$
5.1.2. min at $x = -1$, max at $x = 1$
5.1.3. max at $x = 2$, min at $x = 4$
5.1.4. min at $x = \pm 1$, max at $x = 0$.
5.1.5. min at $x = 1$
5.1.6. none

- 5.1.7. none
- 5.1.8. min at $x = 7\pi/12 + k\pi$, max at $x = -\pi/12 + k\pi$, for integer k .
- 5.1.9. none
- 5.1.10. local max at $x = 5$
- 5.1.11. local min at $x = 49$
- 5.1.12. local min at $x = 0$
- 5.1.13. Local min of 1 at every point of $[0, 1]$, local max of 1 at every point of $(0, 1)$.
- 5.1.16. one
- 5.2.1. min at $x = 1/2$
- 5.2.2. min at $x = -1$, max at $x = 1$
- 5.2.3. max at $x = 2$, min at $x = 4$
- 5.2.4. min at $x = \pm 1$, max at $x = 0$.
- 5.2.5. min at $x = 1$
- 5.2.6. none
- 5.2.7. none
- 5.2.8. min at $x = 7\pi/12 + k\pi$, max at $x = -\pi/12 + k\pi$, for integer k .
- 5.2.9. none
- 5.2.10. max at $x = 0$, min at $x = \pm 11$
- 5.2.11. min at $x = -3/2$, neither at $x = 0$
- 5.2.13. min at $n\pi$, max at $\pi/2 + n\pi$
- 5.2.14. min at $2n\pi$, max at $(2n + 1)\pi$
- 5.2.15. min at $\pi/2 + 2n\pi$, max at $3\pi/2 + 2n\pi$
- 5.3.1. min at $x = 1/2$
- 5.3.2. min at $x = -1$, max at $x = 1$
- 5.3.3. max at $x = 2$, min at $x = 4$
- 5.3.4. min at $x = \pm 1$, max at $x = 0$.
- 5.3.5. min at $x = 1$
- 5.3.6. none
- 5.3.7. none
- 5.3.8. min at $x = 7\pi/12 + n\pi$, max at $x = -\pi/12 + n\pi$, for integer n .
- 5.3.9. max at $x = 63/64$
- 5.3.10. max at $x = 7$
- 5.3.11. max at $-5^{-1/4}$, min at $5^{-1/4}$
- 5.3.12. none
- 5.3.13. max at -1 , min at 1
- 5.3.14. min at $2^{-1/3}$
- 5.3.15. none
- 5.3.16. min at $n\pi$
- 5.3.17. max at $n\pi$, min at $\pi/2 + n\pi$
- 5.3.18. max at $\pi/2 + 2n\pi$, min at $3\pi/2 + 2n\pi$
- 5.4.1. concave up everywhere
- 5.4.2. concave up when $x < 0$, concave down when $x > 0$
- 5.4.3. concave down when $x < 3$, concave up when $x > 3$
- 5.4.4. concave up when $x < -1/\sqrt{3}$ or $x > 1/\sqrt{3}$, concave down when $-1/\sqrt{3} < x < 1/\sqrt{3}$
- 5.4.5. concave up when $x < 0$ or $x > 2/3$, concave down when $0 < x < 2/3$
- 5.4.6. concave up when $x < 0$, concave down when $x > 0$
- 5.4.7. concave up when $x < -1$ or $x > 1$, concave down when $-1 < x < 0$ or $0 < x < 1$
- 5.4.8. concave down on $((8n-1)\pi/4, (8n+3)\pi/4)$, concave up on $((8n+3)\pi/4, (8n+7)\pi/4)$, for integer n
- 5.4.9. concave down everywhere
- 5.4.10. concave up on $(-\infty, (21 - \sqrt{497})/4)$ and $(21 + \sqrt{497})/4, \infty)$

- 5.4.11.** concave up on $(0, \infty)$
5.4.12. concave down on $(2n\pi/3, (2n + 1)\pi/3)$
5.4.13. concave up on $(0, \infty)$
5.4.14. concave up on $(-\infty, -1)$ and $(0, \infty)$
5.4.15. concave down everywhere
5.4.16. concave up everywhere
5.4.17. concave up on $(\pi/4 + n\pi, 3\pi/4 + n\pi)$
5.4.18. inflection points at $n\pi$, $\pm \arcsin(\sqrt{2/3}) + n\pi$
5.4.19. up/incr: $(3, \infty)$, up/decr: $(-\infty, 0)$, $(2, 3)$, down/decr: $(0, 2)$
- 6.1.1.** max at $(2, 5)$, min at $(0, 1)$
6.1.2. 25×25
6.1.3. $P/4 \times P/4$
6.1.4. $w = l = 2 \cdot 5^{2/3}$, $h = 5^{2/3}$, $h/w = 1/2$
6.1.5. $\sqrt[3]{100} \times \sqrt[3]{100} \times 2\sqrt[3]{100}$, $h/s = 2$
6.1.6. $w = l = 2^{1/3}V^{1/3}$, $h = V^{1/3}/2^{2/3}$, $h/w = 1/2$
6.1.7. 1250 square feet
6.1.8. $l^2/8$ square feet
6.1.9. \$5000
6.1.10. 100
6.1.11. r^2
6.1.12. $h/r = 2$
6.1.13. $h/r = 2$
6.1.14. $r = 5$ cm, $h = 40/\pi$ cm, $h/r = 8/\pi$
6.1.15. $8/\pi$
6.1.16. $4/27$
6.1.17. Go direct from D to A .
6.1.18. (a) 2, (b) $7/2$
- 6.1.19.** $\left(\frac{\sqrt{3}}{6}\right) \times \left(\frac{\sqrt{3}}{6} + \frac{1}{2}\right) \times \left(\frac{1}{4} - \frac{\sqrt{3}}{12}\right)$
6.1.20. (a) $a/6$, (b) $(a + b - \sqrt{a^2 - ab + b^2})/6$
6.1.21. 1.5 meters wide by 1.25 meters tall
6.1.22. If $k \leq 2/\pi$ the ratio is $(2 - k\pi)/4$; if $k \geq 2/\pi$, the ratio is zero: the window should be semicircular with no rectangular part.
6.1.23. a/b
6.1.24. $w = 2r/\sqrt{3}$, $h = 2\sqrt{2}r/\sqrt{3}$
6.1.25. $1/\sqrt{3} \approx 58\%$
6.1.26. $18 \times 18 \times 36$
6.1.27. $r = 5/(2\pi)^{1/3} \approx 2.7$ cm,
 $h = 5 \cdot 2^{5/3}/\pi^{1/3} = 4r \approx 10.8$ cm
6.1.28. $h = \frac{750}{\pi} \left(\frac{2\pi^2}{750^2}\right)^{1/3}$, $r = \left(\frac{750^2}{2\pi^2}\right)^{1/6}$
6.1.29. $h/r = \sqrt{2}$
6.1.30. The ratio of the volume of the cone to the volume of the sphere is $1033/4096 + 33\sqrt{17}/4096 \approx 0.2854$, so the cone occupies approximately 28.54% of the sphere.
6.1.31. P should be at distance $c\sqrt[3]{a}/(\sqrt[3]{a} + \sqrt[3]{b})$ from charge A .
6.1.32. $1/2$
6.1.33. \$7000
6.1.34. There is a critical point when $\sin\theta_1/v_1 = \sin\theta_2/v_2$, and the second derivative is positive, so there is a minimum at the critical point.

502 Appendix A Selected Answers

- 6.2.1. $1/(16\pi)$ cm/s
 6.2.2. $3/(1000\pi)$ meters/second
 6.2.3. $1/4$ m/s
 6.2.4. $6/25$ m/s
 6.2.5. 80π mi/min
 6.2.6. $3\sqrt{5}$ ft/s
 6.2.7. $20/(3\pi)$ cm/s
 6.2.8. $13/20$ ft/s
 6.2.9. $5\sqrt{10}/2$ m/s
 6.2.10. $75/64$ m/min
 6.2.11. $145\pi/72$ m/s
 6.2.12. $25\pi/144$ m/min
 6.2.13. $\pi\sqrt{2}/36$ ft³/s
 6.2.14. tip: 6 ft/s, length: $5/2$ ft/s
 6.2.15. tip: $20/11$ m/s, length: $9/11$ m/s
 6.2.16. $380/\sqrt{3} - 150 \approx 69.4$ mph
 6.2.17. $500/\sqrt{3} - 200 \approx 88.7$ km/hr
 6.2.18. 18 m/s
 6.2.19. $136\sqrt{475}/19 \approx 156$ km/hr
 6.2.20. -50 m/s
 6.2.21. 68 m/s
 6.2.22. $3800/\sqrt{329} \approx 210$ km/hr
 6.2.23. $820/\sqrt{329} + 150\sqrt{57}/\sqrt{47} \approx 210$ km/hr
 6.2.24. $4000/49$ m/s
 6.2.25. (a) $x = a \cos \theta - a \sin \theta \cot(\theta + \beta) = a \sin \beta / \sin(\theta + \beta)$, (c) $\dot{x} \approx 3.79$ cm/s
- 6.3.1. $x_3 = 1.475773162$
 6.3.2. 2.15
 6.3.3. 3.36
 6.3.4. 2.19 or 1.26
- 6.4.1. $\Delta y = 65/16, dy = 2$
 6.4.2. $\Delta y = \sqrt{11/10} - 1, dy = 0.05$
 6.4.3. $\Delta y = \sin(\pi/50), dy = \pi/50$
 6.4.4. $dV = 8\pi/25$
- 6.5.1. $c = 1/2$
 6.5.2. $c = \sqrt{18} - 2$
 6.5.6. $x^3/3 + 47x^2/2 - 5x + k$
 6.5.7. $-\cos(2x)/2 + k$
- 7.1.1. 10
 7.1.2. $35/3$
 7.1.3. x^2
 7.1.4. $2x^2$
 7.1.5. $2x^2 - 8$
 7.1.6. $2b^2 - 2a^2$
 7.1.7. 4 rectangles: $41/4 = 10.25$,
 8 rectangles: $183/16 = 11.4375$
 7.1.8. $23/4$
- 7.2.1. $(16/3)x^{3/2} + C$
 7.2.2. $t^3 + t + C$
 7.2.3. $8\sqrt{x} + C$
 7.2.4. $-2/z + C$
 7.2.5. $(5x + 1)^3/15 + C$
 7.2.6. $(x - 6)^3/3 + C$
 7.2.7. $2x^{5/2}/5 + C$
 7.2.8. $-4/\sqrt{x} + C$
 7.2.9. $4t - t^2 + C, t < 2; t^2 - 4t + 8 + C, t \geq 2$
 7.2.10. $87/2$
 7.2.11. 2
 7.2.12. $3^4/4$
 7.2.13. $2^6/6 - 1/6$
 7.2.14. $x^2 - 3x$
 7.2.15. $2x(x^4 - 3x^2)$

- 7.2.16.** $\tan(x^2)$
7.2.17. $2x \tan(x^4)$
7.3.1. It rises until $t = 100/49$, then falls. The position of the object at time t is $s(t) = -4.9t^2 + 20t + k$. The net distance traveled is $-45/2$, that is, it ends up $45/2$ meters below where it started. The total distance traveled is $6205/98$ meters.
7.3.2. $\int_0^{2\pi} \sin t \, dt = 0$
7.3.3. net: 2π , total: $2\pi/3 + 4\sqrt{3}$
7.3.4. 8
7.3.5. $17/3$
7.3.6. $A = 18, B = 44/3, C = 10/3$
7.4.1. $-(1-t)^{10}/10 + C$
7.4.2. $x^5/5 + 2x^3/3 + x + C$
7.4.3. $(x^2 + 1)^{101}/202 + C$
7.4.4. $-3(1-5t)^{2/3}/10 + C$
7.4.5. $(\sin^4 x)/4 + C$
7.4.6. $-(100-x^2)^{3/2}/3 + C$
7.4.7. $-2\sqrt{1-x^3}/3 + C$
7.4.8. $\sin(\sin \pi t)/\pi + C$
7.4.9. $1/(2 \cos^2 x) = (1/2) \sec^2 x + C$
7.4.10. $-\ln |\cos x| + C$
7.4.11. 0
7.4.12. $\tan^2(x)/2 + C$
7.4.13. $1/4$
7.4.14. $-\cos(\tan x) + C$
7.4.15. $1/10$
7.4.16. $\sqrt{3}/4$
7.4.17. $(27/8)(x^2 - 7)^{8/9} + C$
7.4.18. $-(3^7 + 1)/14$
7.4.19. 0
7.4.20. $f(x)^2/2 + C$
8.1.1. $8\sqrt{2}/15$
8.1.2. $1/12$
8.1.3. $9/2$
8.1.4. $4/3$
8.1.5. $2/3 - 2/\pi$
8.1.6. $3/\pi - 3\sqrt{3}/(2\pi) - 1/8$
8.1.7. $1/3$
8.1.8. $10\sqrt{5}/3 - 6$
8.1.9. $500/3$
8.1.10. 2
8.1.11. $1/5$
8.1.12. $1/6$
8.2.1. $1/\pi, 5/\pi$
8.2.2. 0, 245
8.2.3. 20, 28
8.2.4. $(3 - \pi)/(2\pi), (18 - 12\sqrt{3} + \pi)/(4\pi)$
8.2.5. 10/49 meters, 20/49 seconds
8.2.6. 45/98 meters, 30/49 seconds
8.2.7. 25000/49 meters, 1000/49 seconds
8.2.8. $s(t) = \cos t, v(t) = -\sin t$, maximum distance is 1, maximum speed is 1
8.2.9. $s(t) = -\sin(\pi t)/\pi^2 + t/\pi$, $v(t) = -\cos(\pi t)/\pi + 1/\pi$, maximum speed is $2/\pi$
8.2.10. $s(t) = t^2/2 - \sin(\pi t)/\pi^2 + t/\pi$, $v(t) = t - \cos(\pi t)/\pi + 1/\pi$
8.2.11. $s(t) = t^2/2 + \sin(\pi t)/\pi^2 - t/\pi$, $v(t) = t + \cos(\pi t)/\pi - 1/\pi$
8.3.5. $8\pi/3$

- 8.3.6. $\pi/30$
- 8.3.7. $\pi(\pi/2 - 1)$
- 8.3.8. (a) $114\pi/5$ (b) $74\pi/5$ (c) 20π
(d) 4π
- 8.3.9. $16\pi, 24\pi$
- 8.3.11. $\pi h^2(3r - h)/3$
- 8.3.13. 2π
- 8.4.1. $2/\pi; 2/\pi; 0$
- 8.4.2. $4/3$
- 8.4.3. $1/A$
- 8.4.4. $\pi/4$
- 8.4.5. $-1/3, 1$
- 8.4.6. $-4\sqrt{1224}$ ft/s; $-8\sqrt{1224}$ ft/s
- 8.5.1. $\approx 5, 305, 028, 516$ N-m
- 8.5.2. $\approx 4, 457, 854, 041$ N-m
- 8.5.3. $367, 500\pi$ N-m
- 8.5.4. $49000\pi + 196000/3$ N-m
- 8.5.5. 2450π N-m
- 8.5.6. 0.05 N-m
- 8.5.7. $6/5$ N-m
- 8.5.8. 3920 N-m
- 8.5.9. 23520 N-m
- 8.5.10. 12740 N-m
- 9.5.3. $\frac{-1}{1+x^2}$
- 9.5.5. $\frac{2x}{\sqrt{1-x^4}}$
- 9.5.6. $\frac{e^x}{1+e^{2x}}$
- 9.5.7. $-3x^2 \cos(x^3)/\sqrt{1-\sin^2(x^3)}$
- 9.5.8. $\frac{2}{(\arcsin x)\sqrt{1-x^2}}$
- 9.5.9. $-e^x/\sqrt{1-e^{2x}}$
- 9.5.10. 0
- 9.5.11. $\frac{(1+\ln x)x^x}{\ln 5(1+x^{2x})\arctan(x^x)}$
- 9.6.2. $\infty, \infty, 1, 0$
- 10.1.1. $x/2 - \sin(2x)/4 + C$
- 10.1.2. $-\cos x + (\cos^3 x)/3 + C$
- 10.1.3. $3x/8 - (\sin 2x)/4 + (\sin 4x)/32 + C$
- 10.1.4. $(\cos^5 x)/5 - (\cos^3 x)/3 + C$
- 10.1.5. $\sin x - (\sin^3 x)/3 + C$
- 10.1.6. $x/8 - (\sin 4x)/32 + C$
- 10.1.7. $(\sin^3 x)/3 - (\sin^5 x)/5 + C$
- 10.1.8. $-2(\cos x)^{5/2}/5 + C$
- 10.1.9. $\tan x - \cot x + C$
- 10.1.10. $(\sec^3 x)/3 - \sec x + C$
- 10.2.1. $-\ln |\csc x + \cot x| + C$
- 10.2.2. $-\csc x \cot x/2 - (1/2)\ln |\csc x + \cot x| + C$
- 10.2.3. $x\sqrt{x^2-1}/2 - \ln|x+\sqrt{x^2-1}|/2 + C$
- 10.2.4. $x\sqrt{9+4x^2}/2 + (9/4)\ln|2x+\sqrt{9+4x^2}| + C$
- 10.2.5. $-(1-x^2)^{3/2}/3 + C$
- 10.2.6. $\arcsin(x)/8 - \sin(4\arcsin x)/32 + C$
- 10.2.7. $\ln|x+\sqrt{1+x^2}| + C$
- 10.2.8. $(x+1)\sqrt{x^2+2x}/2 - \ln|x+1+\sqrt{x^2+2x}|/2 + C$
- 10.2.9. $-\arctan x - 1/x + C$
- 10.2.10. $2\arcsin(x/2) - x\sqrt{4-x^2}/2 + C$
- 10.2.11. $\arcsin(\sqrt{x}) - \sqrt{x}\sqrt{1-x} + C$
- 10.2.12. $(2x^2+1)\sqrt{4x^2-1}/24 + C$
- 10.3.1. $\cos x + x \sin x + C$
- 10.3.2. $x^2 \sin x - 2 \sin x + 2x \cos x + C$

- 10.3.3.** $(x - 1)e^x + C$
10.3.4. $(1/2)e^{x^2} + C$
10.3.5. $(x/2) - \sin(2x)/4 + C =$
 $(x/2) - (\sin x \cos x)/2 + C$
10.3.6. $x \ln x - x + C$
10.3.7. $(x^2 \arctan x + \arctan x - x)/2 + C$
10.3.8. $-x^3 \cos x + 3x^2 \sin x + 6x \cos x -$
 $6 \sin x + C$
10.3.9. $x^3 \sin x + 3x^2 \cos x - 6x \sin x -$
 $6 \cos x + C$
10.3.10. $x^2/4 - (\cos^2 x)/4 - (x \sin x \cos x)/2 +$
 C
10.3.11. $x/4 - (x \cos^2 x)/2 + (\cos x \sin x)/4 +$
 C
10.3.12. $x \arctan(\sqrt{x}) + \arctan(\sqrt{x}) - \sqrt{x} + C$
10.3.13. $2 \sin(\sqrt{x}) - 2\sqrt{x} \cos(\sqrt{x}) + C$
10.3.14. $\sec x \csc x - 2 \cot x + C$
10.4.1. $-\ln|x - 2|/4 + \ln|x + 2|/4 + C$
10.4.2. $-x^3/3 - 4x - 4 \ln|x - 2| +$
 $4 \ln|x + 2| + C$
10.4.3. $-1/(x + 5) + C$
10.4.4. $-x - \ln|x - 2| + \ln|x + 2| + C$
10.4.5. $-4x + x^3/3 + 8 \arctan(x/2) + C$
10.4.6. $(1/2) \arctan(x/2 + 5/2) + C$
10.4.7. $x^2/2 - 2 \ln(4 + x^2) + C$
10.4.8. $(1/4) \ln|x + 3| - (1/4) \ln|x + 7| + C$
10.4.9. $(1/5) \ln|2x - 3| - (1/5) \ln|1 + x| + C$
10.4.10. $(1/3) \ln|x| - (1/3) \ln|x + 3| + C$
10.5.1. T, S: 4 ± 0
10.5.2. T: 9.28125 ± 0.28125 ; S: 9 ± 0
10.5.3. T: 60.75 ± 1 ; S: 60 ± 0
10.5.4. T: 1.1167 ± 0.0833 ; S: 1.1000 ± 0.0167
10.5.5. T: 0.3235 ± 0.0026 ; S: $0.3217 \pm$
 0.000065
10.5.6. T: 0.6478 ± 0.0052 ; S: $0.6438 \pm$
 0.000033
10.5.7. T: 2.8833 ± 0.0834 ; S: 2.9000 ± 0.0167
10.5.8. T: 1.1170 ± 0.0077 ; S: 1.1114 ± 0.0002
10.5.9. T: 1.097 ± 0.0147 ; S: 1.089 ± 0.0003
10.5.10. T: 3.63 ± 0.087 ; S: 3.62 ± 0.032
10.6.1. $\frac{(t + 4)^4}{4} + C$
10.6.2. $\frac{(t^2 - 9)^{5/2}}{5} + C$
10.6.3. $\frac{(e^{t^2} + 16)^2}{4} + C$
10.6.4. $\cos t - \frac{2}{3} \cos^3 t + C$
10.6.5. $\frac{\tan^2 t}{2} + C$
10.6.6. $\ln|t^2 + t + 3| + C$
10.6.7. $\frac{1}{8} \ln|1 - 4/t^2| + C$
10.6.8. $\frac{1}{25} \tan(\arcsin(t/5)) + C =$
 $\frac{t}{25\sqrt{25 - t^2}} + C$
10.6.9. $\frac{2}{3} \sqrt{\sin 3t} + C$
10.6.10. $t \tan t + \ln|\cos t| + C$
10.6.11. $2\sqrt{e^t + 1} + C$
10.6.12. $\frac{3t}{8} + \frac{\sin 2t}{4} + \frac{\sin 4t}{32} + C$
10.6.13. $\frac{\ln|t|}{3} - \frac{\ln|t + 3|}{3} + C$
10.6.14. $\frac{-1}{\sin \arctan t} + C = -\sqrt{1 + t^2}/t + C$
10.6.15. $\frac{-1}{2(1 + \tan t)^2} + C$
10.6.16. $\frac{(t^2 + 1)^{5/2}}{5} - \frac{(t^2 + 1)^{3/2}}{3} + C$

- 10.6.17. $\frac{e^t \sin t - e^t \cos t}{2} + C$
- 10.6.18. $\frac{(t^{3/2} + 47)^4}{6} + C$
- 10.6.19. $\frac{2}{3(2-t^2)^{3/2}} - \frac{1}{(2-t^2)^{1/2}} + C$
- 10.6.20. $\frac{\ln |\sin(\arctan(2t/3))|}{9} + C = \frac{\ln(4t^2) - \ln(9+4t^2)}{18} + C$
- 10.6.21. $\frac{(\arctan(2t))^2}{4} + C$
- 10.6.22. $\frac{3 \ln |t+3|}{4} + \frac{\ln |t-1|}{4} + C$
- 10.6.23. $\frac{\cos^7 t}{7} - \frac{\cos^5 t}{5} + C$
- 10.6.24. $\frac{-1}{t-3} + C$
- 10.6.25. $\frac{-1}{\ln t} + C$
- 10.6.26. $\frac{t^2(\ln t)^2}{2} - \frac{t^2 \ln t}{2} + \frac{t^2}{4} + C$
- 10.6.27. $(t^3 - 3t^2 + 6t - 6)e^t + C$
- 10.6.28. $\frac{5 + \sqrt{5}}{10} \ln(2t + 1 - \sqrt{5}) + \frac{5 - \sqrt{5}}{10} \ln(2t + 1 + \sqrt{5}) + C$
- 11.1.1. $15/2$
- 11.1.2. 5
- 11.1.3. $16/5$
- 11.1.5. $\bar{x} = 45/28, \bar{y} = 93/70$
- 11.1.6. $\bar{x} = 0, \bar{y} = 4/(3\pi)$
- 11.1.7. $\bar{x} = 1/2, \bar{y} = 2/5$
- 11.1.8. $\bar{x} = 0, \bar{y} = 8/5$
- 11.1.9. $\bar{x} = 4/7, \bar{y} = 2/5$
- 11.1.10. $\bar{x} = \bar{y} = 1/5$
- 11.1.11. $\bar{x} = 0, \bar{y} = 28/(9\pi)$
- 11.1.12. $\bar{x} = \bar{y} = 28/(9\pi)$
- 11.1.13. $\bar{x} = 0, \bar{y} = 244/(27\pi) \approx 2.88$
- 11.2.1. ∞
- 11.2.2. $1/2$
- 11.2.3. diverges
- 11.2.4. diverges
- 11.2.5. 1
- 11.2.6. diverges
- 11.2.7. 2
- 11.2.8. diverges
- 11.2.9. $\pi/6$
- 11.2.10. diverges, 0
- 11.2.11. diverges, 0
- 11.2.12. diverges, no CPV
- 11.2.13. π
- 11.2.14. 80 mph: 90.8 to 95.3 N-m
90 mph: 114.9 to 120.6 N-m
100.9 mph: 144.5 to 151.6 N-m
- 11.3.2. $\mu = 1/c, \sigma = 1/c$
- 11.3.3. $\mu = (a+b)/2, \sigma = \frac{(b-a)}{2\sqrt{3}}$
- 11.3.4. $7/2$
- 11.3.5. $21/2$
- 11.3.9. $r = 6$
- 11.4.1. $(22\sqrt{22} - 8)/27$
- 11.4.2. $\ln(2) + 3/8$
- 11.4.3. $a + a^3/3$
- 11.4.4. $\ln((\sqrt{2} + 1)/\sqrt{3})$
- 11.4.6. $3/4$
- 11.4.7. ≈ 3.82
- 11.4.8. ≈ 1.01
- 11.4.9. $\sqrt{1+e^2} - \sqrt{2} + 1 - \ln(\sqrt{1+e^2} + 1) + \ln(\sqrt{2} + 1)$

- 11.5.1.** $8\pi\sqrt{3} - \frac{16\pi\sqrt{2}}{3}$
11.5.3. $\frac{730\pi\sqrt{730}}{27} - \frac{10\pi\sqrt{10}}{27}$
11.5.4. $\pi + 2\pi e + \frac{1}{4}\pi e^2 - \frac{\pi}{4e^2} - \frac{2\pi}{e}$
11.5.6. $8\pi^2$
11.5.7. $2\pi + \frac{8\pi^2}{3\sqrt{3}}$
11.5.8. $a > b$: $2\pi b^2 + \frac{2\pi a^2 b}{\sqrt{a^2 - b^2}} \arcsin(\sqrt{a^2 - b^2}/a)$,
 $a < b$: $2\pi b^2 + \frac{2\pi a^2 b}{\sqrt{b^2 - a^2}} \ln\left(\frac{b}{a} + \frac{\sqrt{b^2 - a^2}}{a}\right)$
12.1.2. $\theta = \arctan(3)$
12.1.3. $r = -4 \csc \theta$
12.1.4. $r^3 \cos \theta \sin^2 \theta = 1$
12.1.5. $r = \sqrt{5}$
12.1.6. $r^2 = \sin \theta \sec^3 \theta$
12.1.7. $r \sin \theta = \sin(r \cos \theta)$
12.1.8. $r = 2/(\sin \theta - 5 \cos \theta)$
12.1.9. $r = 2 \sec \theta$
12.1.10. $0 = r^2 \cos^2 \theta - r \sin \theta + 1$
12.1.11. $0 = 3r^2 \cos^2 \theta - 2r \cos \theta - r \sin \theta$
12.1.12. $r = \sin \theta$
12.1.21. $(x^2 + y^2)^2 = 4x^2 y - (x^2 + y^2)y$
12.1.22. $(x^2 + y^2)^{3/2} = y^2$
12.1.23. $x^2 + y^2 = x^2 y^2$
12.1.24. $x^4 + x^2 y^2 = y^2$
12.2.1. $(\theta \cos \theta + \sin \theta)/(-\theta \sin \theta + \cos \theta)$,
 $(\theta^2 + 2)/(-\theta \sin \theta + \cos \theta)^3$
12.2.2. $\frac{\cos \theta + 2 \sin \theta \cos \theta}{\cos^2 \theta - \sin^2 \theta - \sin \theta}$,
 $\frac{3(1 + \sin \theta)}{(\cos^2 \theta - \sin^2 \theta - \sin \theta)^3}$
12.2.3. $(\sin^2 \theta - \cos^2 \theta)/(2 \sin \theta \cos \theta)$,
 $-1/(4 \sin^3 \theta \cos^3 \theta)$
12.2.4. $\frac{2 \sin \theta \cos \theta}{\cos^2 \theta - \sin^2 \theta}$, $\frac{2}{(\cos^2 \theta - \sin^2 \theta)^3}$
12.2.5. undefined
12.2.6. $\frac{2 \sin \theta - 3 \sin^3 \theta}{3 \cos^3 \theta - 2 \cos \theta}$,
 $\frac{3 \cos^4 \theta - 3 \cos^2 \theta + 2}{2 \cos^3 \theta (3 \cos^2 \theta - 2)^3}$
12.3.1. 1
12.3.2. $9\pi/2$
12.3.3. $\sqrt{3}/3$
12.3.4. $\pi/12 + \sqrt{3}/16$
12.3.5. πa^2
12.3.6. $41\pi/2$
12.3.7. $2 - \pi/2$
12.3.8. $\pi/12$
12.3.9. $3\pi/16$
12.3.10. $\pi/4 - 3\sqrt{3}/8$
12.3.11. $\pi/2 + 3\sqrt{3}/8$
12.3.12. $1/2$
12.3.13. $3/2 - \pi/4$
12.3.14. $\pi/3 + \sqrt{3}/2$
12.3.15. $\pi/3 - \sqrt{3}/4$
12.3.16. $4\pi^3/3$
12.3.17. π^2
12.3.18. $5\pi/24 - \sqrt{3}/4$
12.3.19. $7\pi/12 - \sqrt{3}$
12.3.20. $4\pi - \sqrt{15}/2 - 7 \arccos(1/4)$
12.3.21. $3\pi^3$
12.4.6. $x = t - \frac{\sin(t)}{2}$, $y = 1 - \frac{\cos(t)}{2}$

- 12.4.7. $x = 4 \cos t - \cos(4t)$,
 $y = 4 \sin t - \sin(4t)$
- 12.4.8. $x = 2 \cos t + \cos(2t)$,
 $y = 2 \sin t - \sin(2t)$
- 12.4.9. $x = \cos t + t \sin t$,
 $y = \sin t - t \cos t$
- 12.5.1. There is a horizontal tangent at all multiples of π .
- 12.5.2. $9\pi/4$
- 12.5.3. $\int_0^{2\pi} \frac{1}{2} \sqrt{5 - 4 \cos t} dt$
- 12.5.4. Four points:
 $\left(\frac{-3 - 3\sqrt{5}}{4}, \pm 5\sqrt{\frac{5 - \sqrt{5}}{8}} \right)$,
 $\left(\frac{-3 + 3\sqrt{5}}{4}, \pm 5\sqrt{\frac{5 + \sqrt{5}}{8}} \right)$
- 12.5.5. $11\pi/3$
- 12.5.6. $32/3$
- 12.5.7. 2π
- 12.5.8. $16/3$
- 12.5.9. $(\pi/2, 1)$
- 12.5.10. $5\pi^3/6$
- 12.5.11. $2\pi^2$
- 12.5.12. $(2\pi\sqrt{4\pi^2 + 1} + \ln(2\pi + \sqrt{4\pi^2 + 1}))/2$
- 13.1.1. 1
- 13.1.3. 0
- 13.1.4. 1
- 13.1.5. 1
- 13.1.6. 0
- 13.2.1. $\lim_{n \rightarrow \infty} n^2/(2n^2 + 1) = 1/2$
- 13.2.2. $\lim_{n \rightarrow \infty} 5/(2^{1/n} + 14) = 1/3$
- 13.2.3. $\sum_{n=1}^{\infty} \frac{1}{n}$ diverges, so $\sum_{n=1}^{\infty} 3\frac{1}{n}$ diverges
- 13.2.4. $-3/2$
- 13.2.5. 11
- 13.2.6. 20
- 13.2.7. $3/4$
- 13.2.8. $3/2$
- 13.2.9. $3/10$
- 13.3.1. diverges
- 13.3.2. diverges
- 13.3.3. converges
- 13.3.4. converges
- 13.3.5. converges
- 13.3.6. converges
- 13.3.7. diverges
- 13.3.8. converges
- 13.3.9. $N = 5$
- 13.3.10. $N = 10$
- 13.3.11. $N = 1687$
- 13.3.12. any integer greater than e^{200}
- 13.4.1. converges
- 13.4.2. converges
- 13.4.3. diverges
- 13.4.4. converges
- 13.4.5. 0.90
- 13.4.6. 0.95
- 13.5.1. converges
- 13.5.2. converges
- 13.5.3. converges
- 13.5.4. diverges
- 13.5.5. diverges

- 13.5.6.** diverges
13.5.7. converges
13.5.8. diverges
13.5.9. converges
13.5.10. diverges
13.6.1. converges absolutely
13.6.2. diverges
13.6.3. converges conditionally
13.6.4. converges absolutely
13.6.5. converges conditionally
13.6.6. converges absolutely
13.6.7. diverges
13.6.8. converges conditionally
13.7.5. converges
13.7.6. converges
13.7.7. converges
13.7.8. diverges
13.8.1. $R = 1, I = (-1, 1)$
13.8.2. $R = \infty, I = (-\infty, \infty)$
13.8.3. $R = e, I = (-e, e)$
13.8.4. $R = e, I = (2 - e, 2 + e)$
13.8.5. $R = 0$, converges only when $x = 2$
13.8.6. $R = 1, I = [-6, -4]$
13.9.1. the alternating harmonic series
13.9.2. $\sum_{n=0}^{\infty} (n+1)x^n$
13.9.3. $\sum_{n=0}^{\infty} (n+1)(n+2)x^n$
13.9.4. $\sum_{n=0}^{\infty} \frac{(n+1)(n+2)}{2} x^n, R = 1$
13.9.5. $C + \sum_{n=0}^{\infty} \frac{-1}{(n+1)(n+2)} x^{n+2}$
13.10.1. $\sum_{n=0}^{\infty} (-1)^n x^{2n} / (2n)!, R = \infty$
13.10.2. $\sum_{n=0}^{\infty} x^n / n!, R = \infty$
13.10.3. $\sum_{n=0}^{\infty} (-1)^n \frac{(x-5)^n}{5^{n+1}}, R = 5$
13.10.4. $\sum_{n=1}^{\infty} (-1)^{n-1} \frac{(x-1)^n}{n}, R = 1$
13.10.5. $\ln(2) + \sum_{n=1}^{\infty} (-1)^{n-1} \frac{(x-2)^n}{n2^n}, R = 2$
13.10.6. $\sum_{n=0}^{\infty} (-1)^n (n+1)(x-1)^n, R = 1$
13.10.7. $1 + \sum_{n=1}^{\infty} \frac{1 \cdot 3 \cdot 5 \cdots (2n-1)}{n!2^n} x^n =$
 $1 + \sum_{n=1}^{\infty} \frac{(2n-1)!}{2^{2n-1}(n-1)!n!} x^n, R = 1$
13.10.8. $x + x^3/3$
13.10.9. $\sum_{n=0}^{\infty} (-1)^n x^{4n+1} / (2n)!$
13.10.10. $\sum_{n=0}^{\infty} (-1)^n x^{n+1} / n!$
13.11.1. $1 - \frac{x^2}{2} + \frac{x^4}{24} - \frac{x^6}{720} + \cdots + \frac{x^{12}}{12!}$
13.11.2. 1000; 8
13.11.3. $x + \frac{x^3}{3} + \frac{2x^5}{15}$, error ± 1.32 .
13.12.1. diverges
13.12.2. converges
13.12.3. converges
13.12.4. diverges
13.12.5. diverges
13.12.6. diverges

- 13.12.7. converges
 13.12.8. converges
 13.12.9. converges
 13.12.10. converges
 13.12.11. converges
 13.12.12. converges
 13.12.13. converges
 13.12.14. converges
 13.12.15. converges
 13.12.16. converges
 13.12.17. diverges
 13.12.18. $(-\infty, \infty)$
 13.12.19. $(-3, 3)$
 13.12.20. $(-3, 3)$
 13.12.21. $(-1, 1)$
 13.12.22. radius is 0—it converges only when $x = 0$
 13.12.23. $(-\sqrt{3}, \sqrt{3})$
 13.12.24. $(-\infty, \infty)$
 13.12.25. $\sum_{n=0}^{\infty} \frac{(\ln(2))^n}{n!} x^n$
 13.12.26. $\sum_{n=0}^{\infty} \frac{(-1)^n}{n+1} x^{n+1}$
 13.12.27. $\sum_{n=0}^{\infty} \frac{2}{2n+1} x^{2n+1}$
 13.12.28. $1 + x/2 + \sum_{n=2}^{\infty} (-1)^{n+1} \frac{1 \cdot 3 \cdot 5 \cdots (2n-3)}{2^n n!} x^n$
 13.12.29. $\sum_{n=0}^{\infty} (-1)^n x^{2n}$
 13.12.30. $\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} x^{2n+1}$
 13.12.31. $\pi = \sum_{n=0}^{\infty} (-1)^n \frac{4}{2n+1}$
 14.1.6. $3, \sqrt{26}, \sqrt{29}$
 14.1.7. $\sqrt{14}, 2\sqrt{14}, 3\sqrt{14}$
 14.1.8. $(x-1)^2 + (y-1)^2 + (z-1)^2 = 4$
 14.1.9. $(x-2)^2 + (y+1)^2 + (z-3)^2 = 25$
 14.1.10. $(x-3)^2 + (y+2)^2 + (z-1)^2 = 33$
 14.1.11. $(x-2)^2 + (y-1)^2 + (z+1)^2 = 16$,
 $(y-1)^2 + (z+1)^2 = 12$
 14.2.6. $\sqrt{10}, \langle 0, -2 \rangle, \langle 2, 8 \rangle, 2, 2\sqrt{17},$
 $\langle -2, -6 \rangle$
 14.2.7. $\sqrt{14}, \langle 0, 4, 0 \rangle, \langle 2, 0, 6 \rangle, 4, 2\sqrt{10},$
 $\langle -2, -4, -6 \rangle$
 14.2.8. $\sqrt{2}, \langle 0, -2, 3 \rangle, \langle 2, 2, -1 \rangle, \sqrt{13}, 3,$
 $\langle -2, 0, -2 \rangle$
 14.2.9. $\sqrt{3}, \langle 1, -1, 4 \rangle, \langle 1, -1, -2 \rangle, 3\sqrt{2},$
 $\sqrt{6}, \langle -2, 2, -2 \rangle$
 14.2.10. $\sqrt{14}, \langle 2, 1, 0 \rangle, \langle 4, 3, 2 \rangle, \sqrt{5}, \sqrt{29},$
 $\langle -6, -4, -2 \rangle$
 14.2.11. $\langle -3, -3, -11 \rangle,$
 $\langle -3/\sqrt{139}, -3/\sqrt{139}, -11/\sqrt{139} \rangle$
 $\langle -12/\sqrt{139}, -12/\sqrt{139}, -44/\sqrt{139} \rangle$
 14.2.12. $\langle 0, 0, 0 \rangle$
 14.2.13. $0; \langle -r\sqrt{3}/2, r/2 \rangle; \langle 0, -12r \rangle;$ where
 r is the radius of the clock
 14.3.1. 3
 14.3.2. 0
 14.3.3. 2
 14.3.4. -6
 14.3.5. 42
 14.3.6. $\sqrt{6}/\sqrt{7}, \approx 0.39$
 14.3.7. $-11\sqrt{14}\sqrt{29}/406, \approx 2.15$

- 14.3.8.** $0, \pi/2$
14.3.9. $1/2, \pi/3$
14.3.10. $-1/\sqrt{3}, \approx 2.19$
14.3.11. $\arccos(1/\sqrt{3}) \approx 0.96$
14.3.12. $\sqrt{5}, \langle 1, 2, 0 \rangle$.
14.3.13. $3\sqrt{14}/7, \langle 9/7, 6/7, 3/7 \rangle$.
14.3.14. $10, 10\sqrt{3}$
14.3.15. $10\sqrt{2}, 10\sqrt{2}$
14.3.16. $\langle 0, 5 \rangle, \langle 5\sqrt{3}, 0 \rangle$
14.3.17. $\langle 0, 15\sqrt{2}/2 \rangle, \langle 15\sqrt{2}/2, 0 \rangle$
14.3.18. $10/\cos(\pi/6) = 20/\sqrt{3}$.
14.3.19. Any vector of the form
 $\langle a, -7a/2, -2a \rangle$
14.3.20. $\langle 1/\sqrt{3}, -1/\sqrt{3}, 1/\sqrt{3} \rangle$
14.3.21. No.
14.3.22. Yes.
14.4.1. $\langle 1, -2, 1 \rangle$
14.4.2. $\langle 4, -6, -2 \rangle$
14.4.3. $\langle -7, 13, -9 \rangle$
14.4.4. $\langle 0, -1, 0 \rangle$
14.4.5. 3
14.4.6. $21\sqrt{2}/2$
14.4.7. 1
14.4.8. 16
14.4.9. $\sqrt{443}/2$
14.4.10. $3\sqrt{166}/2$
14.5.1. $(x - 6) + (y - 2) + (z - 1) = 0$
14.5.2. $4(x + 1) + 5(y - 2) - (z + 3) = 0$
14.5.3. $(x - 1) - (y - 2) = 0$
14.5.4. $-2(x - 1) + 3y - 2z = 0$
14.5.5. $4(x - 1) - 6y = 0$
14.5.6. $7x - y + 11z = 11$
14.5.7. $-68x - 153y + 85z = -1462/7$
14.5.8. $3x - 19y - 10z = -10$
14.5.9. $\langle 1, 0, 3 \rangle + t\langle 0, 2, 1 \rangle$
14.5.10. $\langle 1, 0, 3 \rangle + t\langle 1, 2, -1 \rangle$
14.5.11. $t\langle 1, 1, -1 \rangle$
14.5.12. $-2/5, 13/5$
14.5.14. neither
14.5.15. parallel
14.5.16. intersect at $(3, 6, 5)$
14.5.17. same line
14.5.21. $7/\sqrt{3}$
14.5.22. $4/\sqrt{14}$
14.5.23. $\sqrt{131}/\sqrt{14}$
14.5.24. $\sqrt{68}/3$
14.5.25. $25/\sqrt{198}$
14.5.26. $50/\sqrt{237}$
14.5.27. $3\sqrt{26}/\sqrt{14}$
14.5.28. $\sqrt{3}$
14.5.29. $\sqrt{42}/7$
14.5.30. $\sqrt{21}/6$
14.6.1. $(\sqrt{2}, \pi/4, 1),$
 $(\sqrt{3}, \pi/4, \arccos(1/\sqrt{3}));$
 $(7\sqrt{2}, 7\pi/4, 5),$
 $(\sqrt{123}, 7\pi/4, \arccos(5/\sqrt{123}));$
 $(1, 1, 1), (\sqrt{2}, 1, \pi/4); (0, 0, -\pi),$
 $(\pi, 0, \pi)$
14.6.2. $r^2 + z^2 = 4$
14.6.3. $r \cos \theta = 0$
14.6.4. $r^2 + 2z^2 + 2z - 5 = 0$
14.6.5. $z = e^{-r^2}$
14.6.6. $z = r$

- 14.6.7. $\sin \theta = 0$
- 14.6.8. $1 = \rho \cos \phi$
- 14.6.9. $\rho = 2 \sin \theta \sin \phi$.
- 14.6.10. $\rho \sin \phi = 3$
- 14.6.11. $\phi = \pi/4$
- 14.6.13. $z = mr$; $\cot \phi = m$ if $m \neq 0$, $\phi = 0$ if $m = 0$
- 14.6.14. A sphere with radius $1/2$, center at $(0, 1/2, 0)$
- 14.6.15. $0 < \theta < \pi/2$, $0 < \phi < \pi/2$, $\rho > 0$;
 $0 < \theta < \pi/2$, $r > 0$, $z > 0$
- 15.1.5. $\langle 3 \cos t, 3 \sin t, 2 - 3 \sin t \rangle$
- 15.1.6. $\langle 0, t \cos t, t \sin t \rangle$
- 15.2.1. $\langle 2t, 0, 1 \rangle$, $\mathbf{r}'/\sqrt{1+4t^2}$
- 15.2.2. $\langle -\sin t, 2 \cos 2t, 2t \rangle$,
 $\mathbf{r}'/\sqrt{\sin^2 t + 4 \cos^2(2t) + 4t^2}$
- 15.2.3. $\langle -e^t \sin(e^t), e^t \cos(e^t), \cos t \rangle$,
 $\mathbf{r}'/\sqrt{e^{2t} + \cos^2 t}$
- 15.2.4. $\langle \sqrt{2}/2, \sqrt{2}/2, \pi/4 \rangle +$
 $t \langle -\sqrt{2}/2, \sqrt{2}/2, 1 \rangle$
- 15.2.5. $\langle 1/2, \sqrt{3}/2, -1/2 \rangle +$
 $t \langle -\sqrt{3}/2, 1/2, 2\sqrt{3} \rangle$
- 15.2.6. $2/(\sqrt{5}\sqrt{4+\pi^2})$
- 15.2.7. $7\sqrt{5}\sqrt{17}/85$, $-9\sqrt{5}\sqrt{17}/85$
- 15.2.9. $\langle 0, t \cos t, t \sin t \rangle$, $\langle 0, \cos t -$
 $t \sin t, \sin t + t \cos t \rangle$, $\mathbf{r}'/\sqrt{1+t^2}$,
 $\sqrt{1+t^2}$
- 15.2.10. $\langle \sin t, 1 - \cos t, t^2/2 \rangle$
- 15.2.11. $\langle 1 + t^2/2, 2 + t^3/3, 3 - t^2/2 \rangle$
- 15.2.12. $\langle -4/3 + t^3/3, 1 - \cos t + \cos 1, 2 +$
 $\sin t - \sin 1 \rangle$
- 15.2.13. $t = 4$
- 15.2.14. $\sqrt{37}$, 1
- 15.2.15. $\langle t^2/2, t^3/3, \sin t \rangle$
- 15.2.18. $(1, 1, 1)$ when $t = 1$ and $s = 0$;
 $\theta = \arccos(3/\sqrt{14})$; no
- 15.2.19. $-6x + (y - \pi) = 0$
- 15.2.20. $-x/\sqrt{2} + y/\sqrt{2} + 6z = 0$
- 15.2.21. $(-1, -3, 1)$
- 15.2.22. $\langle 1/\sqrt{2}, 1/\sqrt{2}, 0 \rangle + t \langle -1, 1, 6\sqrt{2} \rangle$
- 15.3.1. $2\pi\sqrt{13}$
- 15.3.2. $(-8 + 13\sqrt{13})/27$
- 15.3.3. $\sqrt{5}/2 + \ln(\sqrt{5} + 2)/4$
- 15.3.4. $(85\sqrt{85} - 13\sqrt{13})/27$
- 15.3.5. $\int_0^5 \sqrt{1+e^{2t}} dt$
- 15.3.6. $2\sqrt{2}/(2+4t^2)^{3/2}$
- 15.3.7. $2\sqrt{2}/(1+8t^2)^{3/2}$
- 15.3.8. $2\sqrt{1+9t^2+9t^4}/(1+4t^2+9t^4)^{3/2}$
- 15.3.9. $12\sqrt{17}/289$
- 15.4.1. $\langle -\sin t, \cos t, 1 \rangle$, $\langle -\cos t, -\sin t, 0 \rangle$,
 $0, 1$
- 15.4.2. $\langle -\sin t, \cos t, 2t \rangle$, $\langle -\cos t, -\sin t, 2 \rangle$,
 $4t/\sqrt{4t^2+1}$, $\sqrt{4t^2+5}/\sqrt{4t^2+1}$
- 15.4.3. $\langle -\sin t, \cos t, e^t \rangle$,
 $\langle -\cos t, -\sin t, e^t \rangle$, $e^{2t}/\sqrt{e^{2t}+1}$,
 $\sqrt{2e^{2t}+1}/\sqrt{e^{2t}+1}$
- 15.4.4. $\langle 2t, 2, 6t - 3 \rangle$, $\langle 2, 0, 6 \rangle$,
 $(40t - 18)/\sqrt{40t^2 - 36t + 13}$,
 $14/\sqrt{40t^2 - 36t + 13}$
- 15.4.5. $\langle e^t, \cos t, e^t \rangle$, $\langle e^t, -\sin t, e^t \rangle$,
 $(2e^{2t} - \cos t \sin t)/\sqrt{2e^{2t} + \cos^2 t}$,
 $\sqrt{2}e^t |\cos t + \sin t|/\sqrt{2e^{2t} + \cos^2 t}$
- 15.4.6. $\langle -3 \sin t, 2 \cos t, 0 \rangle$, $\langle 3 \cos t, 2 \sin t, 0 \rangle$
- 15.4.7. $\langle -3 \sin t, 2 \cos t + 0.1, 0 \rangle$,
 $\langle 3 \cos t, 2 \sin t + t/10, 0 \rangle$

- 15.4.8.** $\langle -3 \sin t, 2 \cos t, 1 \rangle, \langle 3 \cos t, 2 \sin t, t \rangle$
- 15.4.9.** $\langle -3 \sin t, 2 \cos t + 1/10, 1 \rangle,$
 $\langle 3 \cos t, 2 \sin t + t/10, t \rangle$
- 16.1.1.** $z = y^2, z = x^2, z = 0$, lines of slope 1
- 16.1.2.** $z = |y|, z = |x|, z = 2|x|$, diamonds
- 16.1.3.** $z = e^{-y^2} \sin(y^2), z = e^{-x^2} \sin(x^2),$
 $z = e^{-2x^2} \sin(2x^2)$, circles
- 16.1.4.** $z = -\sin(y), z = \sin(x), z = 0$,
 lines of slope 1
- 16.1.5.** $z = y^4, z = x^4, z = 0$, hyperbolas
- 16.1.6.** (a) $\{(x, y) \mid |x| \leq 3 \text{ and } |y| \geq 2\}$
 (b) $\{(x, y) \mid 1 \leq x^2 + y^2 \leq 3\}$
 (c) $\{(x, y) \mid x^2 + 4y^2 \leq 16\}$
- 16.2.1.** No limit; use $x = 0$ and $y = 0$.
- 16.2.2.** No limit; use $x = 0$ and $x = y$.
- 16.2.3.** No limit; use $x = 0$ and $x = y$.
- 16.2.4.** Limit is zero.
- 16.2.5.** Limit is 1.
- 16.2.6.** Limit is zero.
- 16.2.7.** Limit is -1 .
- 16.2.8.** Limit is zero.
- 16.2.9.** No limit; use $x = 0$ and $y = 0$.
- 16.2.10.** Limit is zero.
- 16.2.11.** Limit is -1 .
- 16.2.12.** Limit is zero.
- 16.3.1.** $-2xy \sin(x^2y), -x^2 \sin(x^2y) + 3y^2$
- 16.3.2.** $(y^2 - x^2y)/(x^2 + y^2)^2, x^3/(x^2 + y^2)^2$
- 16.3.3.** $2xe^{x^2+y^2}, 2ye^{x^2+y^2}$
- 16.3.4.** $y \ln(xy) + y, x \ln(xy) + x$
- 16.3.5.** $-x/\sqrt{1 - x^2 - y^2},$
 $-y/\sqrt{1 - x^2 - y^2}$
- 16.3.6.** $\tan y, x \sec^2 y$
- 16.3.7.** $-1/(x^2y), -1/(xy^2)$
- 16.3.8.** $z = -2(x - 1) - 3(y - 1) - 1$
- 16.3.9.** $z = 1$
- 16.3.10.** $z = 6(x - 3) + 3(y - 1) + 10$
- 16.3.11.** $z = (x - 2) + 4(y - 1/2)$
- 16.3.12.** $\mathbf{r}(t) = \langle 2, 1, 4 \rangle + t\langle 2, 4, -1 \rangle$
- 16.3.15.** -0.42
- 16.3.17.** (a) $f'(x)g(y), f(x)g'(y)$; (b)
 $f'(xy)y, f'(xy)x$; (c) $f'(x/y)/y,$
 $-xf'(x/y)/y^2$
- 16.4.1.** $4xt \cos(x^2 + y^2) + 6yt^2 \cos(x^2 + y^2)$
- 16.4.2.** $2xy \cos t + 2x^2t$
- 16.4.3.** $2xyt \cos(st) + 2x^2s, 2xys \cos(st) +$
 $2x^2t$
- 16.4.4.** $2xy^2t - 4yx^2s, 2xy^2s + 4yx^2t$
- 16.4.5.** $x/z, 3y/(2z)$
- 16.4.6.** $-2x/z, -y/z$
- 16.4.7.** $-y^2/(2z), -xy/z$
- 16.4.8.** $z/x, z/y$
- 16.4.9.** (a) $V' = (nR - 0.2V)/P$
 (b) $P' = (nR + 0.6P)/2V$
 (c) $T' = (3P - 0.4V)/(nR)$
- 16.5.1.** $9\sqrt{5}/5$
- 16.5.2.** $\sqrt{2} \cos 3$
- 16.5.3.** $e\sqrt{2}(\sqrt{3} - 1)/4$
- 16.5.4.** $\sqrt{3} + 5$
- 16.5.5.** $-\sqrt{6}(2 + \sqrt{3})/72$
- 16.5.6.** $-1/5, 0$
- 16.5.7.** $4(x - 2) + 8(y - 1) = 0$
- 16.5.8.** $2(x - 3) + 3(y - 2) = 0$
- 16.5.9.** $\langle -1, -1 - \cos 1, -\cos 1 \rangle,$
 $-\sqrt{2 + 2 \cos 1 + 2 \cos^2 1}$

- 16.5.10.** Any direction perpendicular to $\nabla T = \langle 1, 1, 1 \rangle$, for example, $\langle -1, 1, 0 \rangle$
- 16.5.11.** $2(x - 1) - 6(y - 1) + 6(z - 3) = 0$
- 16.5.12.** $6(x - 1) + 3(y - 2) + 2(z - 3) = 0$
- 16.5.13.** $\langle 2 + 4t, -3 - 12t, -1 - 8t \rangle$
- 16.5.14.** $\langle 4 + 8t, 2 + 4t, -2 - 36t \rangle$
- 16.5.15.** $\langle 4 + 8t, 2 + 20t, 6 - 12t \rangle$
- 16.5.16.** $\langle 0, 1 \rangle, \langle 4/5, -3/5 \rangle$
- 16.5.18.** (a) $\langle 4, 9 \rangle, \sqrt{97}$ (b) $\langle -81, 2 \rangle$ or $\langle 81, -2 \rangle$
- 16.5.19.** in the direction of $\langle 8, 1 \rangle$
- 16.5.20.** $\approx 5/8$ knots/mi
- 16.5.21.** $\nabla g(-1, 3) = \langle 2, 1 \rangle$
- 16.6.1.** $f_x = (y^3 - yx^2)/(x^2 + y^2)^2,$
 $f_y = (x^3 - xy^2)/(x^2 + y^2)^2,$
 $f_{xx} = (2x^3y - 6xy^3)/(x^2 + y^2)^3,$
 $f_{yy} = (2xy^3 - 6x^3y)/(x^2 + y^2)^3,$
 $f_{yx} = (6x^2y^2 - x^4 - y^4)/(x^2 + y^2)^3$
- 16.6.2.** $f_x = 3x^2y^2, f_y = 2x^3y + 5y^4,$
 $f_{xx} = 6xy^2, f_{yy} = 2x^3 + 20y^3,$
 $f_{xy} = 6x^2y$
- 16.6.3.** $f_x = 12x^2 + y^2, f_y = 2xy,$
 $f_{xx} = 24x, f_{yy} = 2x, f_{xy} = 2y$
- 16.6.4.** $f_x = \sin y, f_y = x \cos y, f_{xx} = 0,$
 $f_{yy} = -x \sin y, f_{xy} = \cos y$
- 16.6.5.** $f_x = 3 \cos(3x) \cos(2y),$
 $f_y = -2 \sin(3x) \sin(2y),$
 $f_{xy} = -6 \cos(3x) \sin(2y),$
 $f_{yy} = -4 \sin(3x) \cos(2y),$
 $f_{xx} = -9 \sin(3x) \cos(2y)$
- 16.6.6.** $f_x = e^{x+y^2}, f_y = 2ye^{x+y^2},$
 $f_{xx} = e^{x+y^2},$
 $f_{yy} = 4y^2e^{x+y^2} + 2e^{x+y^2},$
 $f_{xy} = 2ye^{x+y^2}$
- 16.6.7.** $f_x = \frac{3x^2}{2(x^3 + y^4)}, f_y = \frac{2y^3}{x^3 + y^4},$
 $f_{xx} = \frac{3x}{x^3 + y^4} - \frac{9x^4}{2(x^3 + y^4)^2},$
 $f_{yy} = \frac{6y^2}{x^3 + y^4} - \frac{8y^6}{(x^3 + y^4)^2},$
 $f_{xy} = \frac{-6x^2y^3}{(x^3 + y^4)^2}$
- 16.6.8.** $z_x = \frac{-x}{16z}, z_y = \frac{-y}{4z},$
 $z_{xx} = -\frac{16z^2 + x^2}{16^2z^3},$
 $z_{yy} = -\frac{4z^2 + y^2}{16z^3},$
 $z_{xy} = \frac{-xy}{64z^3}$
- 16.6.9.** $z_x = -\frac{y+z}{x+y}, z_y = -\frac{x+z}{x+y},$
 $z_{xx} = 2\frac{y+z}{(x+y)^2}, z_{yy} = 2\frac{x+z}{(x+y)^2},$
 $z_{xy} = \frac{2z}{(x+y)^2}$
- 16.7.1.** minimum at $(1, -1)$
- 16.7.2.** none
- 16.7.3.** none
- 16.7.4.** maximum at $(1, -1/6)$
- 16.7.5.** none
- 16.7.6.** minimum at $(2, -1)$
- 16.7.7.** $f(2, 2) = -2, f(2, 0) = 4$
- 16.7.8.** a cube $1/\sqrt[3]{2}$ on a side
- 16.7.9.** $65/3 \cdot 65/3 \cdot 130/3 = 2 \cdot 65^3/27 \approx 20343$ cubic inches.
- 16.7.10.** It has a square base, and is one and one half times as tall as wide. If the volume is V the dimensions are $\sqrt[3]{2V/3} \times \sqrt[3]{2V/3} \times \sqrt[3]{9V/4}$.
- 16.7.11.** $\sqrt{100/3}$

- 16.7.12.** $|ax_0 + by_0 + cz_0 - d|/\sqrt{a^2 + b^2 + c^2}$
- 16.7.13.** The sides and bottom should all be $2/3$ meter, and the sides should be bent up at angle $\pi/3$.
- 16.7.14.** $(3, 4/3)$
- 16.7.16.** $|b|$ if $b \leq 1/2$, otherwise $\sqrt{b - 1/4}$
- 16.7.17.** $|b|$ if $b \leq 1/2$, otherwise $\sqrt{b - 1/4}$
- 16.7.19.** $256/\sqrt{3}$
- 16.8.1.** a cube, $\sqrt[3]{1/2} \times \sqrt[3]{1/2} \times \sqrt[3]{1/2}$
- 16.8.2.** $65/3 \cdot 65/3 \cdot 130/3 = 2 \cdot 65^3/27$
- 16.8.3.** It has a square base, and is one and one half times as tall as wide. If the volume is V the dimensions are $\sqrt[3]{2V/3} \times \sqrt[3]{2V/3} \times \sqrt[3]{9V/4}$.
- 16.8.4.** $|ax_0 + by_0 + cz_0 - d|/\sqrt{a^2 + b^2 + c^2}$
- 16.8.5.** $(0, 0, 1), (0, 0, -1)$
- 16.8.6.** $\sqrt[3]{4V} \times \sqrt[3]{4V} \times \sqrt[3]{V/16}$
- 16.8.7.** Farthest: $(-\sqrt{2}, \sqrt{2}, 2 + 2\sqrt{2})$;
 closest: $(2, 0, 0), (0, -2, 0)$
- 16.8.8.** $x = y = z = 16$
- 16.8.9.** $(1, 2, 2)$
- 16.8.10.** $(\sqrt{5}, 0, 0), (-\sqrt{5}, 0, 0)$
- 16.8.11.** standard \$65, deluxe \$75
- 16.8.12.** $x = y = 2/3, \phi = \pi/3$
- 16.8.13.** 35, -35
- 16.8.14.** maximum e^4 , no minimum
- 16.8.15.** 5, $-9/2$
- 16.8.16.** 3, 3, 3
- 16.8.17.** a cube of side length $2/\sqrt{3}$
- 16.8.18.** An equilateral triangle with side 4.
- 17.1.1.** 16
- 17.1.2.** 4
- 17.1.3.** $15/8$
- 17.1.4.** $1/2$
- 17.1.5.** $5/6$
- 17.1.6.** $12 - 65/(2e)$.
- 17.1.7.** $1/2$
- 17.1.8.** $\pi/64$
- 17.1.9.** $(2/9)2^{3/2} - (2/9)$
- 17.1.10.** $(1 - \cos(1))/4$
- 17.1.11.** $(2\sqrt{2} - 1)/6$
- 17.1.12.** $\pi - 2$
- 17.1.13.** $(e^9 - 1)/6$
- 17.1.14.** $\frac{4}{15} - \frac{\pi}{4}$
- 17.1.15.** $1/3$
- 17.1.16.** 448
- 17.1.17.** $4/5$
- 17.1.18.** 8π
- 17.1.19.** 2
- 17.1.20.** $5/3$
- 17.1.21.** $81/2$
- 17.1.22.** $2a^3/3$
- 17.1.23.** 4π
- 17.1.24.** $\pi/32$
- 17.1.25.** $31/8$
- 17.1.26.** $128/15$
- 17.1.27.** $1800\pi \text{ m}^3$
- 17.1.28.** $\frac{(e^2 + 8e + 16)}{15} \sqrt{e + 4} - \frac{5\sqrt{5}}{3} - \frac{e^{5/2}}{15} + \frac{1}{15}$
- 17.1.30.** $16 - 8\sqrt{2}$

$$17.1.32. \text{ (a) } \int_0^3 \int_0^{9-x^2} f(x, y) dy dx$$

$$\text{ (b) } \int_0^{e^2} \int_{e^y}^2 f(x, y) dx dy$$

$$\text{ (c) } \int_0^{\pi/2} \int_0^{\sin x} f(x, y) dy dx$$

$$\text{ (d) } \int_0^4 \int_0^{y/4} f(x, y) dx dy$$

$$\text{ (e) } \int_0^3 \int_0^{\sqrt{9-x^2}} f(x, y) dy dx$$

$$17.2.1. 4\pi$$

$$17.2.2. 32\pi/3 - 4\sqrt{3}\pi$$

$$17.2.3. (2 - \sqrt{2})\pi/3$$

$$17.2.4. 4/9$$

$$17.2.5. 5\pi/3$$

$$17.2.6. \pi/6$$

$$17.2.7. \pi/2$$

$$17.2.8. \pi/2 - 1$$

$$17.2.9. \sqrt{3}/4 + \pi/6$$

$$17.2.10. 8 + \pi$$

$$17.2.11. \pi/12$$

$$17.2.12. (1 - \cos(9))\pi/2$$

$$17.2.13. -a^5/15$$

$$17.2.14. 12\pi$$

$$17.2.15. \pi$$

$$17.2.16. 16/3$$

$$17.2.17. 21\pi$$

$$17.2.19. 2\pi$$

$$17.3.1. \bar{x} = \bar{y} = 2/3$$

$$17.3.2. \bar{x} = 4/5, \bar{y} = 8/15$$

$$17.3.3. \bar{x} = 0, \bar{y} = 3\pi/16$$

$$17.3.4. \bar{x} = 0, \bar{y} = 16/(15\pi)$$

$$17.3.5. \bar{x} = 3/2, \bar{y} = 9/4$$

$$17.3.6. \bar{x} = 6/5, \bar{y} = 12/5$$

$$17.3.7. \bar{x} = 14/27, \bar{y} = 28/55$$

$$17.3.8. (3/4, 2/5)$$

$$17.3.9. \left(\frac{81\sqrt{3}}{80\pi}, 0 \right)$$

$$17.3.10. \bar{x} = \pi/2, \bar{y} = \pi/8$$

$$17.3.11. M = \int_0^{2\pi} \int_0^{1+\cos\theta} (2 + \cos\theta)r dr d\theta,$$

$$M_x = \int_0^{2\pi} \int_0^{1+\cos\theta} \sin\theta(2 + \cos\theta)r^2 dr d\theta,$$

$$M_y = \int_0^{2\pi} \int_0^{1+\cos\theta} \cos\theta(2 + \cos\theta)r^2 dr d\theta.$$

$$17.3.12. M = \int_{-\pi/2}^{\pi/2} \int_0^{\cos\theta} (r+1)r dr d\theta,$$

$$M_x = \int_{-\pi/2}^{\pi/2} \int_0^{\cos\theta} \sin\theta(r+1)r^2 dr d\theta,$$

$$M_y = \int_{-\pi/2}^{\pi/2} \int_0^{\cos\theta} \cos\theta(r+1)r^2 dr d\theta.$$

$$17.3.13. M = \int_{-\pi/2}^{\pi/2} \int_{\cos\theta}^{1+\cos\theta} r dr d\theta +$$

$$\int_{\pi/2}^{3\pi/2} \int_0^{1+\cos\theta} r dr d\theta,$$

$$M_x = \int_{-\pi/2}^{\pi/2} \int_{\cos\theta}^{1+\cos\theta} r^2 \sin\theta dr d\theta +$$

$$\int_{\pi/2}^{3\pi/2} \int_0^{1+\cos\theta} r^2 \sin\theta dr d\theta,$$

$$M_y = \int_{-\pi/2}^{\pi/2} \int_{\cos\theta}^{1+\cos\theta} r^2 \cos\theta dr d\theta +$$

$$\int_{\pi/2}^{3\pi/2} \int_0^{1+\cos\theta} r^2 \cos\theta dr d\theta.$$

- 17.4.1. $\pi a\sqrt{h^2 + a^2}$
 17.4.2. $\pi a^2\sqrt{m^2 + 1}$
 17.4.3. $\sqrt{3}/2$
 17.4.4. $\pi\sqrt{2}$
 17.4.5. $\pi\sqrt{2}/8$
 17.4.6. $\pi/2 - 1$
 17.4.7. $\frac{d^2\sqrt{a^2 + b^2 + c^2}}{2abc}$
 17.4.8. $8\sqrt{3}\pi/3$
 17.5.1. $11/24$
 17.5.2. $623/60$
 17.5.3. $-3e^2/4 + 2e - 3/4$
 17.5.4. $1/20$
 17.5.5. $\pi/48$
 17.5.6. $11/84$
 17.5.7. $151/60$
 17.5.8. π
 17.5.10. $\frac{3\pi}{16}$
 17.5.11. 32
 17.5.12. $64/3$
 17.5.13. $\bar{x} = \bar{y} = 0, \bar{z} = 16/15$
 17.5.14. $\bar{x} = \bar{y} = 0, \bar{z} = 1/3$
 17.6.1. $\pi/12$
 17.6.2. $\pi(1 - \sqrt{2}/2)$
 17.6.3. $5\pi/4$
 17.6.4. 0
 17.6.5. $5\pi/4$
 17.6.6. $4/5$
 17.6.7. $256\pi/15$
 17.6.8. $4\pi^2$
 17.6.9. $\frac{3\pi}{16}$
 17.6.10. $\pi kh^2 a^2/12$
 17.6.11. $\pi kha^3/6$
 17.6.12. $\pi^2/4$
 17.6.13. $4\pi/5$
 17.6.14. 15π
 17.6.15. $9k\pi(5\sqrt{2} - 2\sqrt{5})/20$
 17.7.1. $4\pi\sqrt{3}/3$
 17.7.2. 0
 17.7.3. $2/3$
 17.7.4. $\frac{e^2 - 1}{2e^2}$
 17.7.5. 36
 17.7.6. $32(\sqrt{2} + \ln(1 + \sqrt{2}))/3$
 17.7.7. $3\cos(1) - 3\cos(4)$
 17.7.8. $\pi(1 - \cos(1))/24$
 17.7.9. $\rho^2 \sin \phi$
 17.7.10. $(4/3)\pi abc$
 18.2.1. $13\sqrt{11}/4$
 18.2.2. 0
 18.2.3. $3\sin(4)/2$
 18.2.4. 0
 18.2.5. $2e^3$
 18.2.6. 128
 18.2.7. $(9e - 3)/2$
 18.2.8. $e^{e+1} - e^e - e^{1/e-1} + e^{1/e} + e^4/4 - e^{-4}/4$
 18.2.9. $1 + \sin(1) - \cos(1)$
 18.2.10. $3\ln 3 - 2\ln 2$
 18.2.11. $3/20 + 10\ln(2)/7$
 18.2.12. $2\ln 5 - 2\ln 2 + 15/32$
 18.2.13. 1
 18.2.14. $21 + \cos(1) - \cos(8)$
 18.2.15. $(\ln 29 - \ln 2)/2$

- 18.2.16.** $2 \ln 2 + \pi/4 - 2$
18.2.17. $1243/3$
18.2.18. $\ln 2 + 11/3$
18.2.19. $3 \cos(1) - \cos(2) - \cos(4) - \cos(8)$
18.2.20. $-10/3$
18.3.1. no f
18.3.2. $x^4/4 - y^5/5$
18.3.3. no f
18.3.4. no f
18.3.5. $y \sin x$
18.3.6. no f
18.3.7. xyz
18.3.8. -144
18.3.9. 6
18.3.10. $1/e - \sin 3$
18.3.11. $1/\sqrt{77} - 1/\sqrt{3}$
18.4.1. 1
18.4.2. 0
18.4.3. $1/(2e) - 1/(2e^7) + e/2 - e^7/2$
18.4.4. $1/2$
18.4.5. $-1/6$
18.4.6. $(2\sqrt{3} - 10\sqrt{5} + 8\sqrt{6})/3 - 2\sqrt{2}/5 + 1/5$
18.4.7. $11/2 - \ln(2)$
18.4.8. $2 - \pi/2$
18.4.9. $-17/12$
18.4.10. 0
18.4.11. $-\pi/2$
18.4.12. 12π
18.4.13. $2 \cos(1) - 2 \sin(1) - 1$
18.5.1. $-1, 0$
18.5.2. $0, a + b$
18.5.3. $(2b - a)/3, 0$
18.5.4. $0, 1$
18.5.5. $-2\pi, 0$
18.5.6. $0, 2\pi$
18.6.3. $25\sqrt{21}/4$
18.6.4. $\pi\sqrt{21}$
18.6.5. $\pi(5\sqrt{5} - 1)/6$
18.6.6. $4\pi\sqrt{2}$
18.6.7. $\pi a^2/2$
18.6.8. $2\pi a(a - \sqrt{a^2 - b^2})$
18.6.9. $\pi((1 + 4a^2)^{3/2} - 1)/6$
18.6.10. $2\pi((1 + a^2)^{3/2} - 1)/3$
18.6.11. $\pi a^2 - 2a^2$
18.6.12. $\pi a^2 \sqrt{1 + k^2}/4$
18.6.13. $A\sqrt{1 + a^2 + b^2}$
18.6.14. $A\sqrt{k^2 + 1}$
18.6.15. $8a^2$
18.7.1. $(0, 0, 3/8)$
18.7.2. $(11/20, 11/20, 3/10)$
18.7.3. $(0, 0, 2275/682)$
18.7.4. on center axis, $h/3$ above the base
18.7.5. 16
18.7.6. 7
18.7.7. $-\pi$
18.7.8. $-137/120$
18.7.9. $-2/e$
18.7.10. $\pi b^2(-4b^4 - 3b^2 + 6a^2b^2 + 6a^2)/6$
18.7.11. 9280 kg/s
18.7.12. $24\epsilon_0$
18.8.1. -3π
18.8.2. 0
18.8.3. -4π

- 18.8.4.** 3π
18.8.5. $A(p(c-b) + q(a-c) + a-b)$
18.9.1. both are $-45\pi/4$
18.9.2. $a^2bc + ab^2c + abc^2$
18.9.3. $e^2 - 2e + 7/2$
18.9.4. 3
18.9.5. $384\pi/5$
18.9.6. $\pi/3$
18.9.7. 10π
18.9.8. $\pi/2$
19.1.2. $y = \arctan t + C$
19.1.3. $y = \frac{t^{n+1}}{n+1} + 1$
19.1.4. $y = t \ln t - t + C$
19.1.5. $y = n\pi$, for any integer n .
19.1.6. none
19.1.7. $y = \pm\sqrt{t^2 + C}$
19.1.8. $y = \pm 1$, $y = (1 + Ae^{2t})/(1 - Ae^{2t})$
19.1.9. $y^4/4 - 5y = t^2/2 + C$
19.1.10. $y = (2t/3)^{3/2}$
19.1.11. $y = M + Ae^{-kt}$
19.1.12. $\frac{10 \ln(15/2)}{\ln 5} - 10 \approx 2.52$ minutes
19.1.13. $y = \frac{M}{1 + Ae^{-Mkt}}$
19.1.14. $y = 2e^{3t/2}$
19.1.15. $t = -\frac{\ln 2}{k}$
19.1.16. $600e^{-6 \ln 2/5} \approx 261$ mg; $\frac{5 \ln 300}{\ln 2} \approx 41$ days
19.1.17. $100e^{-200 \ln 2/191} \approx 48$ mg;
 $\frac{5730 \ln 50}{\ln 2} \approx 32339$ years
19.1.18. $y = y_0 e^{t \ln 2}$
19.1.19. $500e^{-5 \ln 2/4} \approx 210$ g
19.2.1. $y = Ae^{-5t}$
19.2.2. $y = Ae^{2t}$
19.2.3. $y = Ae^{-\arctan t}$
19.2.4. $y = Ae^{-t^3/3}$
19.2.5. $y = 4e^{-t}$
19.2.6. $y = -2e^{3t-3}$
19.2.7. $y = e^{1+\cos t}$
19.2.8. $y = e^2 e^{-e^t}$
19.2.9. $y = 0$
19.2.10. $y = 0$
19.2.11. $y = 4t^2$
19.2.12. $y = -2e^{(1/t)-1}$
19.2.13. $y = e^{1-t^{-2}}$
19.2.14. $y = 0$
19.2.15. $k = \ln 5$, $y = 100e^{-t \ln 5}$
19.2.16. $k = -12/13$, $y = \exp(-13t^{1/13})$
19.2.17. $y = 10^6 e^{t \ln(3/2)}$
19.2.18. $y = 10e^{-t \ln(2)/6}$
19.3.1. $y = Ae^{-4t} + 2$
19.3.2. $y = Ae^{2t} - 3$
19.3.3. $y = Ae^{-(1/2)t^2} + 5$
19.3.4. $y = Ae^{-e^t} - 2$
19.3.5. $y = Ae^t - t^2 - 2t - 2$
19.3.6. $y = Ae^{-t/2} + t - 2$
19.3.7. $y = At^2 - \frac{1}{3t}$
19.3.8. $y = \frac{c}{t} + \frac{2}{3}\sqrt{t}$
19.3.9. $y = A \cos t + \sin t$
19.3.10. $y = \frac{A}{\sec t + \tan t} + 1 - \frac{t}{\sec t + \tan t}$

- 19.4.1.** $y(1) \approx 1.355$
19.4.2. $y(1) \approx 40.31$
19.4.3. $y(1) \approx 1.05$
19.4.4. $y(1) \approx 2.30$
19.5.4. $\frac{\omega + 1}{2\omega}e^{\omega t} + \frac{\omega - 1}{2\omega}e^{-\omega t}$
19.5.5. $2 \cos(3t) + 5 \sin(3t)$
19.5.6. $-(1/4)e^{-5t} + (5/4)e^{-t}$
19.5.7. $-2e^{-3t} + 2e^{4t}$
19.5.8. $5e^{-6t} + 20te^{-6t}$
19.5.9. $(16t - 3)e^{4t}$
19.5.10. $-2 \cos(\sqrt{5}t) + \sqrt{5} \sin(\sqrt{5}t)$
19.5.11. $-\sqrt{2} \cos t + \sqrt{2} \sin t$
19.5.12. $e^{-6t} (4 \cos t + 24 \sin t)$
19.5.13. $2e^{-3t} \sin(3t)$
19.5.14. $2 \cos(2t - \pi/6)$
19.5.15. $5\sqrt{2} \cos(10t - \pi/4)$
19.5.16. $\sqrt{2}e^{-2t} \cos(3t - \pi/4)$
19.5.17. $5e^{4t} \cos(3t + \arcsin(4/5))$
19.5.18. $(2 \cos(5t) + \sin(5t))e^{-2t}$
19.5.19. $-(1/2)e^{-2t} \sin(2t)$
19.6.1. $Ae^{5t} + Bte^{5t} + (6/169) \cos t - (5/338) \sin t$
19.6.2. $Ae^{-\sqrt{2}t} + Bte^{-\sqrt{2}t} + 5$
19.6.3. $A \cos(4t) + B \sin(4t) + (1/2)t^2 + (3/16)t - 5/16$
19.6.4. $A \cos(\sqrt{2}t) + B \sin(\sqrt{2}t) - (\cos(5t) + \sin(5t))/23$
19.6.5. $e^t (A \cos t + B \sin t) + e^{2t}/2$
19.6.6. $Ae^{\sqrt{6}t} + Be^{-\sqrt{6}t} + 2 - t/3 - e^{-t}/5$
19.6.7. $Ae^{-3t} + Be^{2t} - (1/5)te^{-3t}$
19.6.8. $Ae^t + Be^{3t} + (1/2)te^{3t}$
19.6.9. $A \cos(4t) + B \sin(4t) + (1/8)t \sin(4t)$
19.6.10. $A \cos(3t) + B \sin(3t) - (1/2)t \cos(3t)$
19.6.11. $Ae^{-6t} + Bte^{-6t} + 3t^2e^{-6t}$
19.6.12. $Ae^{4t} + Bte^{4t} - t^2e^{4t}$
19.6.13. $Ae^{-t} + Be^{-5t} + (4/5)$
19.6.14. $Ae^{4t} + Be^{-3t} + (1/144) - (t/12)$
19.6.15. $A \cos(\sqrt{5}t) + B \sin(\sqrt{5}t) + 8 \sin(2t)$
19.6.16. $Ae^{2t} + Be^{-2t} + te^{2t}$
19.6.17. $4e^t + e^{-t} - 3t - 5$
19.6.18. $-(4/27) \sin(3t) + (4/9)t$
19.6.19. $e^{-6t}(2 \cos t + 20 \sin t) + 2e^{-4t}$
19.6.20. $\left(-\frac{23}{325} \cos(3t) + \frac{592}{975} \sin(3t)\right) e^{-3t} + \frac{23}{325} \cos t - \frac{11}{325} \sin t$
19.6.21. $e^{-2t}(A \sin(5t) + B \cos(5t)) + 8 \sin(2t) + 25 \cos(2t)$
19.6.22. $e^{-2t}(A \sin(2t) + B \cos(2t)) + (14/195) \sin t - (8/195) \cos t$
19.7.1. $A \sin(t) + B \cos(t) - \cos t \ln |\sec t + \tan t|$
19.7.2. $A \sin(t) + B \cos(t) + \frac{1}{5}e^{2t}$
19.7.3. $A \sin(2t) + B \cos(2t) + \cos t - \sin t \cos t \ln |\sec t + \tan t|$
19.7.4. $A \sin(2t) + B \cos(2t) + \frac{1}{2} \sin(2t) \sin^2(t) + \frac{1}{2} \sin(2t) \ln |\cos t| - \frac{t}{2} \cos(2t) + \frac{1}{4} \sin(2t) \cos(2t)$
19.7.5. $Ae^{2t} + Be^{-3t} + \frac{t^3}{15}e^{2t} - \left(\frac{t^2}{5} - \frac{2t}{25} + \frac{2}{125}\right) \frac{e^{2t}}{5}$

$$19.7.6. Ae^t \sin t + Be^t \cos t - e^t \cos t \ln |\sec t + \tan t|$$

$$19.7.7. Ae^t \sin t + Be^t \cos t - \frac{1}{10} \cos t (\cos^3 t + 3 \sin^3 t - 2 \cos t - \sin t) +$$

$$\frac{1}{10} \sin t (\sin^3 t - 3 \cos^3 t - 2 \sin t + \cos t) = Ae^t \sin t + Be^t \cos t + \frac{1}{10} \cos(2t) - \frac{1}{20} \sin(2t)$$

