

B

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: $3/2, \text{ no } x$ -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. $y = 75t, 164$ 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) $(x + 5)^2 + (y + 6)^2 = 9$
- 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. $\{x \mid x \geq 1\}$
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. $3x^2$
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. $-(9/7)x^{-16/7}$
3.1.7. $-98t^2/10$, $-98/10$
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. $-49t/5 + 5, -49/5$
3.2.12. $\sum_{k=1}^n ka_k x^{k-1}$
3.2.13. $x^3/16 - 3x/4 + 4$
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. $y = 23x/96 - 29/96$
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. $120x^4 - 576x^3 + 888x^2 - 480x + 96$

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. $y = 3 - 2x/3$

3.5.37. $y = 13x/2 - 23/2$

3.5.38. $y = 2x - 11$

3.5.39. $y = \frac{20 + 2\sqrt{5}}{5\sqrt{4 + \sqrt{5}}}x + \frac{3\sqrt{5}}{5\sqrt{4 + \sqrt{5}}}$

4.1.1. $2n\pi - \pi/2$, any integer n

4.1.2. $n\pi \pm \pi/6$, any integer n

4.1.11. $t = \pi/2$

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. $\sin \theta / (\cos \theta + 1)^2$

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. $\sqrt{3}x/2 + 3/4 - \sqrt{3}\pi/6$

4.5.16. $8\sqrt{3}x + 4 - 8\sqrt{3}\pi/3$

4.5.17. $3\sqrt{3}x/2 - \sqrt{3}\pi/4$

4.5.18. $\pi/6 + 2n\pi, 5\pi/6 + 2n\pi$, any integer n

4.7.1. $2 \ln(3)x3^{x^2}$

4.7.2. $\frac{\cos x - \sin x}{e^x}$

4.7.3. $2e^{2x}$

4.7.4. $e^x \cos(e^x)$

4.7.5. $\cos(x)e^{\sin x}$

4.7.6. $x^{\sin x} \left(\cos x \ln x + \frac{\sin x}{x} \right)$

- 4.7.7. $3x^2e^x + x^3e^x$
- 4.7.8. $1 + 2^x \ln(2)$
- 4.7.9. $-2x \ln(3)(1/3)^{x^2}$
- 4.7.10. $e^{4x}(4x - 1)/x^2$
- 4.7.11. $(3x^2 + 3)/(x^3 + 3x)$
- 4.7.12. $-\tan(x)$
- 4.7.13. $(1 - \ln(x^2))/(x^2\sqrt{\ln(x^2)})$
- 4.7.14. $\sec(x)$
- 4.7.15. $x^{\sin(x)}(\cos(x) \ln(x) + \sin(x)/x)$
- 4.7.16. e
- 4.8.1. 0
- 4.8.2. ∞
- 4.8.3. 1
- 4.8.4. 0
- 4.8.5. 0
- 4.8.6. $y = 1$ and $y = -1$
- 4.9.1. x/y
- 4.9.2. $-(2x + y)/(x + 2y)$
- 4.9.3. $-(3x^2 + y^2 - 2xy)/(2xy - 3y^2 - x^2)$
- 4.9.4. $y \sin(x)/\cos(x)$
- 4.9.5. $-\sqrt{y}/\sqrt{x}$
- 4.9.6. $(y \sec^2(x/y) - y^2)/(x \sec^2(x/y) + y^2)$
- 4.9.7. $(y - \cos(x + y))/(\cos(x + y) - x)$
- 4.9.8. $-y^2/x^2$
- 4.9.9. 1
- 4.9.11. $y = 2x \pm 6$
- 4.9.12. $y = x/2 \pm 3$
- 4.9.13. $(\sqrt{3}, 2\sqrt{3}), (-\sqrt{3}, -2\sqrt{3}),$
 $(2\sqrt{3}, \sqrt{3}), (-2\sqrt{3}, -\sqrt{3})$
- 4.9.14. $y = 7x/\sqrt{3} - 8/\sqrt{3}$
- 4.9.15. $y = (-y_1^{1/3}x + y_1^{1/3}x_1 + x_1^{1/3}y_1)/x_1^{1/3}$
- 4.9.16. $(y - y_1)/(x - x_1) = (2x_1^3 + 2x_1y_1^2 - x_1)/(2y_1^3 + 2y_1x_1^2 + y_1)$
- 4.10.3. $-1/(1 + x^2)$
- 4.10.4. $\frac{2x}{\sqrt{1 - x^4}}$
- 4.10.5. $\frac{e^x}{1 + e^{2x}}$
- 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 $x = 0$
- 5.1.15. 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. $w = l = 2^{1/3}V^{1/3}$, $h = V^{1/3}/2^{2/3}$, $h/w = 1/2$
- 6.1.6. 1250 square feet
- 6.1.7. $l^2/8$ square feet

- 6.1.8. \$5000
- 6.1.9. r^2
- 6.1.10. $h/r = 2$
- 6.1.11. $8/\pi$
- 6.1.12. $4/27$
- 6.1.13. Go direct from A to D .
- 6.1.14. (a) 2, (b) $7/2$
- 6.1.15. (a) $a/6$, (b) $(a+b-\sqrt{a^2-ab+b^2})/6$
- 6.1.16. 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.
- 6.1.17. a/b
- 6.1.18. $w = 2r/\sqrt{3}$, $h = 2\sqrt{2}r/\sqrt{3}$
- 6.1.19. $1/\sqrt{3} \approx 58\%$
- 6.1.20. $18 \times 18 \times 36$
- 6.1.21. $r = 5/(2\pi)^{1/3} \approx 2.7$ cm,
 $h = 5 \cdot 2^{5/3}/\pi^{1/3} = 4r \approx 10.8$ cm
- 6.1.22. $h/r = \sqrt{2}$
- 6.1.23. The ratio of the volume of the sphere to the volume of the cone is $1033/4096 + 33/4096\sqrt{17} \approx 0.2854$, so the cone occupies approximately 28.54% of the sphere.
- 6.1.24. P should be at distance $c\sqrt[3]{a}/(\sqrt[3]{a} + \sqrt[3]{b})$ from charge A .
- 6.1.25. $1/2$
- 6.1.26. \$7000
- 6.1.27. 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.
- 6.2.1. $1/(16\pi)$ cm/s
- 6.2.2. $1/4$ m/s
- 6.2.3. 80π mi/min
- 6.2.4. $3\sqrt{5}$ ft/s
- 6.2.5. $20/(3\pi)$ cm/s
- 6.2.6. $13/20$ ft/s
- 6.2.7. $5\sqrt{10}/2$ m/s
- 6.2.8. $75/64$ m/min
- 6.2.9. $25\pi/144$ m/min
- 6.2.10. $\pi\sqrt{2}/36$ ft³/s
- 6.2.11. tip: 6 ft/s, length: $5/2$ ft/s
- 6.2.12. $380/\sqrt{3} - 150 \approx 69.4$ mph
- 6.2.13. $136\sqrt{475}/19 \approx 156$ km/hr
- 6.2.14. -50 m/s
- 6.2.15. 68 m/s
- 6.2.16. $3800/\sqrt{329} \approx 210$ km/hr
- 6.2.17. $820/\sqrt{329} + 150\sqrt{57}/\sqrt{47} \approx 210$ km/hr
- 6.2.18. $4000/49$ m/s
- 6.2.19. (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. 2.19 or 1.26
- 6.4.1. $c = 1/2$
- 6.4.4. $x^3/3 + 47x^2/2 - 5x + k$
- 6.4.5. $\arctan x + k$
- 6.4.6. $x^4/4 - \ln x + k$
- 6.4.7. $-\cos(2x)/2 + k$
- 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. $7 \ln s + C$

7.2.6. $(5x + 1)^3/15 + C$

7.2.7. $(x - 6)^3/3 + C$

7.2.8. $2x^{5/2}/5 + C$

7.2.9. $-4/\sqrt{x} + C$

7.2.10. $4t - t^2 + C, t < 2; t^2 - 4t + 8 + C,$
 $t \geq 2$

7.2.11. $87/2$

7.2.12. 2

7.2.13. $\ln(10)$

7.2.14. $e^5 - 1$

7.2.15. $3^4/4$

7.2.16. $2^6/6 - 1/6$

7.2.17. $x^2 - 3x$

7.2.18. $2x(x^4 - 3x^2)$

7.2.19. e^{x^2}

7.2.20. $2xe^{x^4}$

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. $A = 18, B = 44/3, C = 10/3$

8.1.1. $-(1 - t)^{10}/10 + C$

8.1.2. $x^5/5 + 2x^3/3 + x + C$

8.1.3. $(x^2 + 1)^{101}/202 + C$

8.1.4. $-3(1 - 5t)^{2/3}/10 + C$

8.1.5. $(\sin^4 x)/4 + C$

8.1.6. $-(100 - x^2)^{3/2}/3 + C$

8.1.7. $-2\sqrt{1 - x^3}/3 + C$

8.1.8. $\sin(\sin \pi t)/\pi + C$

8.1.9. $1/(2 \cos^2 x) = (1/2) \sec^2 x + C$

8.1.10. $-\ln |\cos x| + C$

8.2.1. $x/2 - \sin(2x)/4 + C$

8.2.2. $-\cos x + (\cos^3 x)/3 + C$

8.2.3. $3x/8 - (\sin 2x)/4 + (\sin 4x)/32 + C$

8.2.4. $(\cos^5 x)/5 - (\cos^3 x)/3 + C$

8.2.5. $\sin x - (\sin^3 x)/3 + C$

8.2.6. $x/8 - (\sin 4x)/32 + C$

8.2.7. $(\sin^3 x)/3 - (\sin^5 x)/5 + C$

8.2.8. $-2(\cos x)^{5/2}/5 + C$

8.2.9. $\tan x - \cot x + C$

8.2.10. $(\sec^3 x)/3 - \sec x + C$

8.3.1. $x\sqrt{x^2 - 1}/2 - \ln |x + \sqrt{x^2 - 1}|/2 + C$

8.3.2. $x\sqrt{9 + 4x^2}/2 +$
 $(9/4) \ln |2x + \sqrt{9 + 4x^2}| + C$

8.3.3. $-(1 - x^2)^{3/2}/3 + C$

8.3.4. $\arcsin(x)/8 - \sin(4 \arcsin x)/32 + C$

- 8.3.5. $\ln|x + \sqrt{1+x^2}| + C$
- 8.3.6. $(x+1)\sqrt{x^2+2x}/2 - \ln|x+1+\sqrt{x^2+2x}|/2 + C$
- 8.3.7. $-\arctan x - 1/x + C$
- 8.3.8. $2\arcsin(x/2) - x\sqrt{4-x^2}/2 + C$
- 8.3.9. $\arcsin(\sqrt{x}) - \sqrt{x}\sqrt{1-x} + C$
- 8.3.10. $(2x^2+1)\sqrt{4x^2-1}/24 + C$
- 8.4.1. $\cos x + x \sin x + C$
- 8.4.2. $x^2 \sin x - 2 \sin x + 2x \cos x + C$
- 8.4.3. $(x-1)e^x + C$
- 8.4.4. $(1/2)e^{x^2} + C$
- 8.4.5. $(x/2) - \sin(2x)/4 + C = (x/2) - (\sin x \cos x)/2 + C$
- 8.4.6. $x \ln x - x + C$
- 8.4.7. $(x^2 \arctan x + \arctan x - x)/2 + C$
- 8.4.8. $-x^2 \cos x + 2x \sin x + 2 \cos x + C$
- 8.4.9. $x^2/4 - (\cos^2 x)/4 - (x \sin x \cos x)/2 + C$
- 8.4.10. $x/4 - (x \cos^2 x)/2 + (\cos x \sin x)/4 + C$
- 8.4.11. $x \arctan(\sqrt{x}) + \arctan(\sqrt{x}) - \sqrt{x} + C$
- 8.4.12. $2 \sin(\sqrt{x}) - 2\sqrt{x} \cos(\sqrt{x}) + C$
- 8.5.1. $-\ln|x-2|/4 + \ln|x+2|/4 + C$
- 8.5.2. $-x^3/3 - 4x - 4 \ln|x-2| + 4 \ln|x+2| + C$
- 8.5.3. $-1/(x+5) + C$
- 8.5.4. $-x - \ln|x-2| + \ln|x+2| + C$
- 8.5.5. $-4x + x^3/3 + 8 \arctan(x/2) + C$
- 8.5.6. $(1/2) \arctan(x/2 + 5/2) + C$
- 8.5.7. $x^2/2 - 2 \ln(4+x^2) + C$
- 8.5.8. $(1/4) \ln|x+3| - (1/4) \ln|x+7| + C$
- 8.5.9. $(1/5) \ln|2x-3| - (1/5) \ln|1+x| + C$
- 8.5.10. $(1/3) \ln|x| - (1/3) \ln|x+3| + C$
- 8.6.1. $\frac{(t+4)^4}{4} + C$
- 8.6.2. $\frac{(t^2-9)^{5/2}}{5} + C$
- 8.6.3. $\frac{(e^{t^2}+16)^2}{4} + C$
- 8.6.4. $\cos t - \frac{2}{3} \cos^3 t + C$
- 8.6.5. $\frac{\tan^2 t}{2} + C$
- 8.6.6. $\ln|t^2+t+3| + C$
- 8.6.7. $\frac{1}{8} \ln|1-4/t^2| + C$
- 8.6.8. $\frac{t^2}{4} - \frac{t \sin(2t)}{4} - \frac{\cos(2t)}{8} + C$
- 8.6.9. $\frac{1}{25} \tan(\arcsin(t/5)) + C = \frac{t}{25\sqrt{25-t^2}} + C$
- 8.6.10. $\frac{2}{3} \sqrt{\sin 3t} + C$
- 8.6.11. $t \tan t + \ln|\cos t| + C$
- 8.6.12. $2\sqrt{e^t+1} + C$
- 8.6.13. $\frac{3t}{8} + \frac{\sin 2t}{4} + \frac{\sin 4t}{32} + C$
- 8.6.14. $\frac{\ln|t|}{3} - \frac{\ln|t+3|}{3} + C$
- 8.6.15. $\frac{-1}{\sin \arctan t} + C = -\sqrt{1+t^2}/t + C$
- 8.6.16. $\frac{-1}{2(1+\tan t)^2} + C$
- 8.6.17. $\frac{(t^2+1)^{5/2}}{5} - \frac{(t^2+1)^{3/2}}{3} + C$
- 8.6.18. $\frac{e^t \sin t - e^t \cos t}{2} + C$
- 8.6.19. $\frac{(t^{3/2}+47)^4}{6} + C$

- 8.6.20. $\frac{2}{3(2-t^2)^{3/2}} - \frac{1}{(2-t^2)^{1/2}} + C$
- 8.6.21. $\frac{\ln|\sin(\arctan(2t/3))|}{9} + C = \frac{(\ln(4t^2) - \ln(9+4t^2))/18 + C}{1}$
- 8.6.22. $\frac{(\arctan(2t))^2}{4} + C$
- 8.6.23. $\frac{3 \ln|t+3|}{4} + \frac{\ln|t-1|}{4} + C$
- 8.6.24. $\frac{\cos^7 t}{7} - \frac{\cos^5 t}{5} + C$
- 8.6.25. $\frac{-1}{t-3} + C$
- 8.6.26. $\frac{-1}{\ln t} + C$
- 8.6.27. $\frac{t^2(\ln t)^2}{2} - \frac{t^2 \ln t}{2} + \frac{t^2}{4} + C$
- 8.6.28. $(t^3 - 3t^2 + 6t - 6)e^t + C$
- 8.6.29. $\frac{5 + \sqrt{5}}{10} \ln(2t + 1 - \sqrt{5}) + \frac{5 - \sqrt{5}}{10} \ln(2t + 1 + \sqrt{5}) + C$
- 9.1.1. $8\sqrt{2}/15$
- 9.1.2. $1/12$
- 9.1.3. $9/2$
- 9.1.4. $4/3$
- 9.1.5. $2/3 - 2/\pi$
- 9.1.6. $3/\pi - 3\sqrt{3}/(2\pi) - 1/8$
- 9.1.7. $1/3$
- 9.1.8. $10\sqrt{5}/3 - 6$
- 9.1.9. $500/3$
- 9.1.10. 2
- 9.1.11. $1/5$
- 9.1.12. $1/6$
- 9.2.1. $1/\pi, 5/\pi$
- 9.2.2. $0, 245$
- 9.2.3. $20, 28$
- 9.2.4. $(3 - \pi)/(2\pi), (18 - 12\sqrt{3} + \pi)/(4\pi)$
- 9.2.5. $10/49$ meters, $20/49$ seconds
- 9.2.6. $45/98$ meters, $30/49$ seconds
- 9.2.7. $25000/49$ meters, $1000/49$ seconds
- 9.2.8. $s(t) = \cos t, v(t) = -\sin t$,
maximum distance is 1,
maximum speed is 1
- 9.2.9. $s(t) = -\sin(\pi t)/\pi^2 + t/\pi$,
 $v(t) = -\cos(\pi t)/\pi + 1/\pi$,
maximum speed is $2/\pi$
- 9.2.10. $s(t) = t^2/2 - 2\sin(\pi t)/\pi^2 + 2t/\pi$,
 $v(t) = t - 2\cos(\pi t)/\pi + 2/\pi$
- 9.2.11. $s(t) = t^2/2 + 2\sin(\pi t)/\pi^2 - 2t/\pi$,
 $v(t) = t + 2\cos(\pi t)/\pi - 2/\pi$
- 9.3.5. $8\pi/3$
- 9.3.6. $\pi/30$
- 9.3.7. $\pi(\pi/2 - 1)$
- 9.3.8. (a) $114\pi/5$ (b) $74\pi/5$ (c) 20π
(d) 4π
- 9.3.9. $16\pi, 24\pi$
- 9.3.11. $\pi h^2(3r - h)/3$
- 9.3.12. $s^3/8$
- 9.3.13. 2π
- 9.4.1. $2/\pi; 2/\pi; 0$
- 9.4.2. $4/3$
- 9.4.3. $1/A$
- 9.4.4. $\pi/4$
- 9.4.5. $-1/3, 1$
- 9.4.6. $-4\sqrt{1224}$ ft/s; $-8\sqrt{1224}$ ft/s
- 9.5.1. $\approx 5,305,028,517$ N-m
- 9.5.2. $\approx 4,457,854,041$ N-m

- 9.5.3.** $367, 500\pi$ N-m
9.5.4. $49000\pi + 196000/3$
9.5.5. 2450π N-m
9.5.6. 0.05 N-m
9.5.7. $6/5$ N-m
9.5.8. 3920 N-m
9.5.9. 23520 N-m
9.6.1. $15/2$
9.6.2. 5
9.6.3. $16/5$
9.6.5. $\bar{x} = 45/28, \bar{y} = 93/70$
9.6.6. $\bar{x} = 0, \bar{y} = 4/(3\pi)$
9.6.7. $\bar{x} = 1/2, \bar{y} = 2/5$
9.6.8. $\bar{x} = 0, \bar{y} = 8/5$
9.6.9. $\bar{x} = 4/7, \bar{y} = 2/5$
9.6.10. $\bar{x} = \bar{y} = 1/5$
9.6.11. $\bar{x} = 0, \bar{y} = 28/(9\pi)$
9.6.12. $\bar{x} = \bar{y} = 28/(9\pi)$
9.7.1. ∞
9.7.2. $1/2$
9.7.3. diverges
9.7.4. diverges
9.7.5. diverges
9.7.6. 2
9.7.7. π
9.7.8. 80 mph: 90.8 to 95.3 N
 90 mph: 114.9 to 120.6 N
 110.9 mph: 144.5 to 151.6 N
10.1.1. 1
10.1.3. 0
10.1.4. 1
10.1.5. 1
10.1.6. 0
10.2.1. $\lim_{n \rightarrow \infty} n^2/(2n^2 + 1) = 1/2$
10.2.2. $\lim_{n \rightarrow \infty} 5/(2^{1/n} + 14) = 1/3$
10.2.3. $s_n = 3(1 + 1/2 + \cdots + 1/n) = 3t_n$,
 where t_n is the partial sum of the
 harmonic series. Since $\lim t_n = \infty$,
 $\lim s_n = \infty$.
10.2.4. $-3/2$
10.2.5. 11
10.3.1. diverges
10.3.2. diverges
10.3.3. converges
10.3.4. converges
10.3.5. converges
10.3.6. converges
10.3.7. diverges
10.3.8. converges
10.3.9. $N = 5$
10.3.10. $N = 10$
10.4.1. converges
10.4.2. converges
10.4.3. diverges
10.4.4. converges
10.4.5. 0.90
10.4.6. 0.95
10.5.1. converges
10.5.2. converges
10.5.3. converges
10.5.4. diverges
10.5.5. diverges
10.5.6. diverges

- 10.5.7. converges
 10.5.8. diverges
 10.5.9. converges
 10.5.10. diverges
 10.6.1. converges absolutely
 10.6.2. diverges
 10.6.3. converges conditionally
 10.6.4. converges absolutely
 10.6.5. converges conditionally
 10.6.6. converges absolutely
 10.6.7. diverges
 10.6.8. converges conditionally
 10.7.5. converges
 10.7.6. converges
 10.7.7. converges
 10.7.8. diverges
 10.8.1. $R = 1, I = (-1, 1)$
 10.8.2. $R = \infty, I = (-\infty, \infty)$
 10.8.3. $R = e, I = (-e, e)$
 10.8.4. $R = e, I = (2 - e, 2 + e)$
 10.8.5. $R = 0$, converges only when $x = 2$
 10.8.6. $R = 1, I = (-6, -4)$
 10.9.1. the alternating harmonic series
 10.9.2. $\sum_{n=0}^{\infty} (n+1)x^n$
 10.9.3. $\sum_{n=0}^{\infty} (n+1)(n+2)x^n$
 10.9.4. $\sum_{n=0}^{\infty} \frac{(n+1)(n+2)}{2} x^n, R = 1$
 10.9.5. $C + \sum_{n=0}^{\infty} \frac{-1}{(n+1)(n+2)} x^{n+2}$
 10.10.1. $\sum_{n=0}^{\infty} (-1)^n x^{2n} / (2n)!, R = \infty$
 10.10.2. $\sum_{n=0}^{\infty} x^n / n!, R = \infty$
 10.10.3. $\sum_{n=0}^{\infty} (-1)^n \frac{(x-5)^n}{5^{n+1}}, R = 5$
 10.10.4. $\sum_{n=1}^{\infty} (-1)^{n-1} \frac{(x-1)^n}{n}, R = 1$
 10.10.5. $\ln(2) + \sum_{n=1}^{\infty} (-1)^{n-1} \frac{(x-2)^n}{n2^n}, R = 2$
 10.10.6. $\sum_{n=0}^{\infty} (-1)^n (n+1)(x-1)^n, R = 1$
 10.10.7. $1 + \sum_{n=1}^{\infty} \frac{1 \cdot 3 \cdot 5 \cdots (2n-1)}{n!2^n} x^n =$
 $1 + \sum_{n=1}^{\infty} \frac{(2n-1)!}{2^{2n-1}(n-1)!n!} x^n, R = 1$
 10.10.8. $x + x^3/3$
 10.10.9. $\sum_{n=0}^{\infty} (-1)^n x^{4n+1} / (2n)!$
 10.10.10. $\sum_{n=0}^{\infty} (-1)^n x^{n+1} / n!$
 10.11.1. $1 - \frac{x^2}{2} + \frac{x^4}{24} - \frac{x^6}{720} + \cdots + \frac{x^{12}}{12!}$
 10.11.2. 1000; 8
 10.11.3. $x + \frac{x^3}{3} + \frac{2x^5}{15}$, error ± 4.26 .
 10.12.1. diverges
 10.12.2. converges
 10.12.3. converges
 10.12.4. diverges
 10.12.5. diverges

10.12.6. diverges

10.12.7. converges

10.12.8. converges

10.12.9. converges

10.12.10. converges

10.12.11. converges

10.12.12. converges

10.12.13. converges

10.12.14. converges

10.12.15. converges

10.12.16. converges

10.12.17. $(-\infty, \infty)$

10.12.18. $(-3, 3)$

10.12.19. $(-3, 3)$

10.12.20. $(-1, 1)$

10.12.21. radius is 0—it converges only when $x = 0$

10.12.22. $(-\sqrt{3}/2, \sqrt{3}/2)$

10.12.23. $(-\infty, \infty)$

10.12.24. $\sum_{n=0}^{\infty} \frac{(\ln(2))^n}{n!} x^n$

10.12.25. $\sum_{n=0}^{\infty} \frac{(-1)^n}{n+1} x^{n+1}$

10.12.26. $\sum_{n=0}^{\infty} \frac{2}{2n+1} x^{2n+1}$

10.12.27. $1 + x/2 +$

$$\sum_{n=0}^{\infty} (-1)^{n+1} \frac{1 \cdot 3 \cdot 5 \cdots (2n-3)}{2^n n!} x^{-(2n-1)/2}$$

10.12.28. $\sum_{n=0}^{\infty} (-1)^n x^{2n}$

10.12.29. $\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} x^{2n+1}$

10.12.30. $\pi = \sum_{n=0}^{\infty} (-1)^n \frac{4}{2n+1}$

11.1.6. $(x-1)^2 + (y-1)^2 + (z-1)^2 = 4.$

11.1.7. $(x-2)^2 + (y+1)^2 + (z-3)^2 = 25.$

11.1.9. $(x-2)^2 + (y-1)^2 + (z+1)^2 = 16,$
 $(y-1)^2 + (z+1)^2 = 12$

11.2.6. $\sqrt{10}, \langle 0, -2 \rangle, \langle 2, 8 \rangle, 2, 2\sqrt{17},$
 $\langle -2, -6 \rangle$

11.2.7. $\sqrt{14}, \langle 0, 4, 0 \rangle, \langle 2, 0, 6 \rangle, 4, 2\sqrt{10},$
 $\langle -2, -4, -6 \rangle$

11.2.8. $\sqrt{2}, \langle 0, -2, 3 \rangle, \langle 2, 2, -1 \rangle, \sqrt{13}, 3,$
 $\langle -2, 0, -2 \rangle$

11.2.9. $\sqrt{3}, \langle 1, -1, 4 \rangle, \langle 1, -1, -2 \rangle, 3\sqrt{2}, \sqrt{6},$
 $\langle -2, 2, -2 \rangle$

11.2.10. $\sqrt{14}, \langle 2, 1, 0 \rangle, \langle 4, 3, 2 \rangle, \sqrt{5}, \sqrt{29},$
 $\langle -6, -4, -2 \rangle$

11.3.1. 3

11.3.2. 0

11.3.3. 2

11.3.4. -6

11.3.5. 42

11.3.6. $\sqrt{6}/\sqrt{7}, \approx 0.39$

11.3.7. $11\sqrt{14}\sqrt{29}/406, \approx 2.15$

11.3.8. $0, \pi/2$

11.3.9. $1/2, \pi/3$

11.3.10. $-1/\sqrt{3}, \approx 2.19$

11.3.11. $\arccos(1/\sqrt{3}) \approx 0.96$

11.3.12. $\sqrt{5}, \langle 1, 2, 0 \rangle.$

11.3.13. $3\sqrt{14}/7, \langle 9/7, 6/7, 3/7 \rangle.$

11.3.14. $\langle 0, 5 \rangle, \langle 5\sqrt{3}, 0 \rangle$

11.3.15. $\langle 0, 15\sqrt{2}/2 \rangle, \langle 15\sqrt{2}/2, 0 \rangle$

- 11.4.1.** $\langle 1, -2, 1 \rangle$
11.4.2. $\langle 4, -6, -2 \rangle$
11.4.3. $\langle -7, 13, -9 \rangle$
11.4.4. $\langle 0, -1, 0 \rangle$
11.4.5. 3
11.5.1. $(x - 6) + (y - 2) + (z - 1) = 0$
11.5.2. $4(x + 1) + 5(y - 2) - (z + 3) = 0$
11.5.3. $(x - 1) - (y - 2) = 0$
11.5.4. $-2(x - 1) + 3y - 2z = 0$
11.5.5. $4(x - 1) - 6y = 0$
11.5.6. $x + 3y = 0$
11.5.7. $\langle 1, 0, 3 \rangle + t\langle 0, 2, 1 \rangle$
11.5.8. $\langle 1, 0, 3 \rangle + t\langle 1, 2, -1 \rangle$
11.5.9. $t\langle 1, 1, -1 \rangle$
11.5.10. $-2/5, 13/5$
11.5.12. neither
11.5.13. parallel
11.5.14. intersect
11.5.15. same line
11.6.1. $(\sqrt{2}, \pi/4, 1),$
 $(\sqrt{3}, \pi/4, \arccos(1/\sqrt{3}));$
 $(7\sqrt{2}, 7\pi/4, 5),$
 $(\sqrt{123}, 7\pi/4, \arccos(5/\sqrt{123}));$
 $(1, 1, 1), (\sqrt{2}, 1, \pi/4); (0, 0, -\pi),$
 $(\pi, 0, \pi)$
11.6.2. $r^2 + z^2 = 4$
11.6.3. $r \cos \theta = 0$
11.6.4. $r^2 + 2z^2 + 2z - 5 = 0$
11.6.5. $z = e^{-r^2}$
11.6.6. $z = r$
11.6.7. $\sin \theta = 0$
11.6.8. $1 = \rho \cos \phi$
11.6.9. $\rho = 2 \sin \theta \sin \phi.$
11.6.10. $\rho \sin \phi = 2$
11.6.11. $\cos \phi = 1/\sqrt{2}$
12.1.5. $\langle 3 \cos t, 3 \sin t, 2 - 3 \sin t \rangle$
12.1.6. $\langle 0, t \cos t, t \sin t \rangle$
12.2.1. $\langle 2t, 0, 1 \rangle, \mathbf{r}'/\sqrt{1 + 4t^2}$
12.2.2. $\langle -\sin t, 2 \cos 2t, 2t \rangle,$
 $\mathbf{r}'/\sqrt{\sin^2 t + 4 \cos^2(2t) + 4t^2}$
12.2.3. $\langle -e^t \sin(e^t), e^t \cos(e^t), \cos t \rangle,$
 $\mathbf{r}'/\sqrt{e^{2t} + \cos^2 t}$
12.2.4. $\langle \sqrt{2}/2, \sqrt{2}/2, \pi/4 \rangle +$
 $t\langle -\sqrt{2}/2, \sqrt{2}/2, 1 \rangle$
12.2.5. $\langle 1/2, \sqrt{3}/2, -1/2 \rangle +$
 $t\langle -\sqrt{3}/2, 1/2, 2\sqrt{3} \rangle$
12.2.6. $2/\sqrt{5}/\sqrt{4 + \pi^2}$
12.2.7. $7\sqrt{5}\sqrt{17}/85, -9\sqrt{5}\sqrt{17}/85$
12.2.9. $\langle 0, t \cos t, t \sin t \rangle, \langle 0, \cos t -$
 $t \sin t, \sin t + t \cos t \rangle, \mathbf{r}'/\sqrt{1 + t^2},$
 $\sqrt{1 + t^2}$
12.2.10. $\langle \sin t, 1 - \cos t, t^2/2 \rangle$
12.2.11. $\langle t^2/2, t^3/3, \sin t \rangle$
12.3.1. $2\pi\sqrt{13}$
12.3.2. $(-8 + 13\sqrt{13})/27$
12.3.3. $\sqrt{5}/2 + \ln(\sqrt{5} + 2)/4$
12.3.4. $(85\sqrt{85} - 13\sqrt{13})/27$
12.3.5. $\int_0^5 \sqrt{1 + e^{2t}} dt$
12.3.6. $2\sqrt{2}/(2 + 4t^2)^{3/2}$
12.3.7. $2\sqrt{2}/(1 + 8t^2)^{3/2}$
12.3.8. $2\sqrt{1 + 9t^2 + 9t^4}/(1 + 4t^2 + 9t^4)^{3/2}$
12.4.1. $\langle -\sin t, \cos t, 1 \rangle, \langle -\cos t, -\sin t, 0 \rangle,$
 $0, 1$

- 12.4.2.** $\langle -\sin t, \cos t, 2t \rangle, \langle -\cos t, -\sin t, 2 \rangle,$
 $4t/\sqrt{4t^2 + 1}, \sqrt{4t^2 + 5}/\sqrt{4t^2 + 1}$
- 12.4.3.** $\langle -\sin t, \cos t, e^t \rangle,$
 $\langle -\cos t, -\sin t, e^t \rangle, e^{2t}/\sqrt{e^{2t} + 1},$
 $\sqrt{2e^{2t} + 1}/\sqrt{e^{2t} + 1}$
- 12.4.4.** $\langle e^t, \cos t, e^t \rangle, \langle e^t, -\sin t, e^t \rangle,$
 $(2e^{2t} - \cos t \sin t)/\sqrt{2e^{2t} + \cos^2 t},$
 $\sqrt{2e^t} |\cos t + \sin t|/\sqrt{2e^{2t} + \cos^2 t}$
- 12.4.5.** $\langle -3 \sin t, 2 \cos t, 0 \rangle, \langle 3 \cos t, 2 \sin t, 0 \rangle$
- 12.4.6.** $\langle -3 \sin t, 2 \cos t + 0.1, 0 \rangle,$
 $\langle 3 \cos t, 2 \sin t + t/10, 0 \rangle$
- 12.4.7.** $\langle -3 \sin t, 2 \cos t, 1 \rangle, \langle 3 \cos t, 2 \sin t, t \rangle$
- 12.4.8.** $\langle -3 \sin t, 2 \cos t + 1/10, 1 \rangle,$
 $\langle 3 \cos t, 2 \sin t + t/10, t \rangle$
- 13.1.1.** $z = y^2, z = x^2, z = 0,$ lines of slope 1
- 13.1.2.** $z = |y|, z = |x|, z = 2|x|,$ diamonds
- 13.1.3.** $z = e^{-y^2} \sin(y^2), z = e^{-x^2} \sin(x^2),$
 $z = e^{-2x^2} \sin(2x^2),$ circles
- 13.1.4.** $z = -\sin(y), z = \sin(x), z = 0,$
 lines of slope 1
- 13.1.5.** $z = y^4, z = x^4, z = 0,$ hyperbolas
- 13.2.1.** No limit; use $x = 0$ and $y = 0$.
- 13.2.2.** No limit; use $x = 0$ and $x = y$.
- 13.2.3.** No limit; use $x = 0$ and $x = y$.
- 13.2.4.** Limit is zero.
- 13.2.5.** Limit is 1.
- 13.2.6.** Limit is zero.
- 13.3.1.** $-2xy \sin(x^2y), -x^2 \sin(x^2y) + 3y^2$
- 13.3.2.** $(y^2 - x^2y)/(x^2 + y)^2, x^3/(x^2 + y)^2$
- 13.3.3.** $2xe^{x^2+y^2}, 2ye^{x^2+y^2}$
- 13.3.4.** $y \ln(xy) + y, x \ln(xy) + x$
- 13.3.5.** $-x/\sqrt{1 - x^2 - y^2},$
 $-y/\sqrt{1 - x^2 - y^2}$
- 13.3.6.** $\tan y, x \sec^2 y$
- 13.3.7.** $-1/(x^2y), -1/(xy^2)$
- 13.3.8.** $z = -2(x - 1) - 3(y - 1) - 1$
- 13.3.9.** $z = 1$
- 13.3.10.** $z = 6(x - 3) + 3(y - 1) + 10$
- 13.3.11.** $z = (x - 2) + 4(y - 1/2)$
- 13.3.12.** $\mathbf{r}(t) = \langle 2, 1, 4 \rangle + t\langle 2, 4, -1 \rangle$
- 13.4.1.** $4xt \cos(x^2 + y^2) + 6yt^2 \cos(x^2 + y^2)$
- 13.4.2.** $2xy \cos t + 2x^2t$
- 13.4.3.** $2xyt \cos(st) + 2x^2s, 2xys \cos(st) +$
 $2x^2t$
- 13.4.4.** $2xy^2t - 4yx^2s, 2xy^2s + 4yx^2t$
- 13.4.5.** $x/z, 3y/(2z)$
- 13.4.6.** $-2x/z, -y/z$
- 13.5.1.** $9\sqrt{5}/5$
- 13.5.2.** $\sqrt{2} \cos 3$
- 13.5.3.** $e\sqrt{2}(\sqrt{3} - 1)/4$
- 13.5.4.** $\sqrt{3} + 5$
- 13.5.5.** $-\sqrt{6}(2 + \sqrt{3})/72$
- 13.5.6.** $-1/5, 0$
- 13.5.7.** $4(x - 2) + 8(y - 1) = 0$
- 13.5.8.** $2(x - 3) + 3(y - 2) = 0$
- 13.5.9.** $\langle -1, -1 - \cos 1, -\cos 1 \rangle,$
 $-\sqrt{2 + 2 \cos 1 + 2 \cos^2 1}$
- 13.5.10.** Any direction perpendicular to
 $\nabla T = \langle 1, 1, 1 \rangle,$ for example,
 $\langle -1, 1, 0 \rangle$
- 13.5.11.** $2(x - 1) - 6(y - 1) + 6(z - 3) = 0$
- 13.5.12.** $6(x - 1) + 3(y - 2) + 2(z - 3) = 0$
- 13.5.13.** $\langle 2 + 4t, -3 - 12t, -1 - 8t \rangle$

- 13.5.14. $\langle 4 + 8t, 2 + 4t, -2 - 36t \rangle$
- 13.5.15. $\langle 4 + 8t, 2 + 20t, 6 - 12t \rangle$
- 13.6.1. $f_{xx} = (2x^3y - 6xy^3)/(x^2 + y^2)^3$,
 $f_{yy} = (2xy^3 - 6x^3y)/(x^2 + y^2)^3$
- 13.6.2. $f_x = 3x^2y^2$, $f_y = 2x^3y + 5y^4$,
 $f_{xx} = 6xy^2$, $f_{yy} = 2x^3 + 20y^3$,
 $f_{xy} = 6x^2y$
- 13.6.3. $f_x = 12x^2 + y^2$, $f_y = 2xy$, $f_{xx} = 24x$,
 $f_{yy} = 2x$, $f_{xy} = 2y$
- 13.6.4. $f_x = \sin y$, $f_y = x \cos y$, $f_{xx} = 0$,
 $f_{yy} = -x \sin y$, $f_{xy} = \cos y$
- 13.7.1. minimum at $(1, -1)$
- 13.7.2. none
- 13.7.3. none
- 13.7.4. maximum at $(1, -1/6)$
- 13.7.5. none
- 13.7.6. minimum at $(2, -1)$
- 13.7.7. a cube $1/\sqrt[3]{2}$ on a side
- 13.7.8. $65/3 \times 65/3 \times 130/3$
- 13.7.9. It has a square base, and is one and one half times as tall as wide. If the volume is V the dimensions are $\sqrt[3]{2V/3} \times \sqrt[3]{2V/3} \times \sqrt[3]{9V/4}$.
- 13.7.10. $\sqrt{100/3}$
- 13.7.11. $|ax_0 + by_0 + cz_0 - d|/\sqrt{a^2 + b^2 + c^2}$
- 13.7.12. The sides and bottom should all be $2/3$ meter, and the sides should be bent up at angle $\pi/3$.
- 13.7.13. $(3, 4/3)$
- 13.8.1. a cube
- 13.8.2. $65/3 \times 65/3 \times 130/3$
- 13.8.3. It has a square base, and is one and one half times as tall as wide. If the volume is V the dimensions are $\sqrt[3]{2V/3} \times \sqrt[3]{2V/3} \times \sqrt[3]{9V/4}$.
- 13.8.4. $|ax_0 + by_0 + cz_0 - d|/\sqrt{a^2 + b^2 + c^2}$
- 13.8.5. $(0, 0, 1)$, $(0, 0, -1)$
- 13.8.6. $\sqrt[3]{4V} \times \sqrt[3]{4V} \times \sqrt[3]{V/16}$
- 13.8.7. Farthest: $(-\sqrt{2}, \sqrt{2}, 2 + 2\sqrt{2})$;
closest: $(2, 0, 0)$, $(0, -2, 0)$
- 14.1.1. 16
- 14.1.2. 4
- 14.1.3. $15/8$
- 14.1.4. $1/2$
- 14.1.5. $5/6$
- 14.1.6. $12 - 65/(2e)$.
- 14.1.7. $1/2$
- 14.1.8. $\pi/64$
- 14.1.9. $(2/9)2^{3/2} - (2/9)$
- 14.1.10. $(1 - \cos(1))/4$
- 14.1.11. $(2\sqrt{2} - 1)/6$
- 14.1.12. $\pi - 2$
- 14.1.13. 8π
- 14.1.14. 2
- 14.1.15. $5/3$
- 14.1.16. $81/2$
- 14.1.17. $2a^3/3$
- 14.1.18. 4π
- 14.1.19. $\pi/32$
- 14.1.22. $16 - 8\sqrt{2}$
- 14.2.1. 4π
- 14.2.2. $32\pi/3 - 4\sqrt{3}\pi$
- 14.2.3. $(2 - \sqrt{2})\pi/3$
- 14.2.4. $4/9$

- 14.2.5. $5\pi/3$
 14.2.6. $\pi/6$
 14.2.7. $\pi/2$
 14.2.8. $\pi/2 - 1$
 14.2.9. $\sqrt{3}/4 + \pi/6$
 14.3.1. $\bar{x} = \bar{y} = 2/3$
 14.3.2. $\bar{x} = 4/5, \bar{y} = 8/15$
 14.3.3. $\bar{x} = 0, \bar{y} = 3\pi/16$
 14.3.4. $\bar{x} = 0, \bar{y} = 16/(15\pi)$
 14.4.1. $\pi a\sqrt{h^2 + a^2}$
 14.4.2. $\pi a^2\sqrt{m^2 + 1}$
 14.4.3. $\sqrt{3}/2$
 14.4.4. $\pi\sqrt{2}$
 14.4.5. $\pi\sqrt{2}/8$
 14.4.6. $\pi/2 - 1$
 14.5.1. $11/24$
 14.5.2. $623/60$
 14.5.3. $-3e^2/4 + 2e - 3/4$
 14.5.4. $1/20$
 14.5.5. $\pi/48$
 14.5.6. $11/84$
 14.5.7. $151/60$
 14.5.9. 32
 14.5.10. $64/3$
 14.5.11. $\bar{x} = \bar{y} = 0, \bar{z} = 16/15$
 14.5.12. $\bar{x} = \bar{y} = 0, \bar{z} = 1/3$
 14.6.1. $\pi/12$
 14.6.2. $5\pi/4$
 14.6.3. 0
 14.6.4. $5\pi/4$
 14.6.5. $4/5$
 14.6.6. $256\pi/15$
 14.6.7. $4\pi^2$
 14.6.8. $\pi kh^2 a^2/12$
 14.6.9. $\pi kha^3/6$
 14.6.10. $\pi^2/4$
 14.6.11. $4\pi/5$
 14.6.12. $124\pi/5$
 14.7.2. 0
 14.7.3. $2/3$
 14.7.6. $32(\sqrt{2} + \ln(1 + \sqrt{2}))/3$
 14.7.7. $3\cos(1) - 3\cos(4)$
 15.2.1. $13\sqrt{11}/4$
 15.2.2. 0
 15.2.3. $3\sin(4)/2$
 15.2.4. 0
 15.2.5. $2e^3$
 15.2.6. 128
 15.2.7. $(9e - 3)/2$
 15.2.8. $e^{e+1} - e^e - e^{1/e-1} + e^{1/e} + e^4/4 - e^{-4}/4$
 15.2.9. $1 + \sin(1) - \cos(1)$
 15.2.10. $3\ln 3 - 2\ln 2$
 15.2.11. $3/20 + 10\ln(2)/7$
 15.2.12. $2\ln 5 - 2\ln 2 + 15/32$
 15.2.13. 1
 15.2.14. 0
 15.2.15. $21 + \cos(1) - \cos(8)$
 15.2.16. $(\ln 29 - \ln 2)/2$
 15.2.17. $2\ln 2 + \pi/4 - 2$
 15.2.18. $1243/3$
 15.2.19. $\ln 2 + 11/3$

- 15.2.20.** $3 \cos(1) - \cos(2) - \cos(4) - \cos(8)$
15.2.21. $-10/3$
15.3.1. no f
15.3.2. $x^4/4 - y^5/5$
15.3.3. no f
15.3.4. no f
15.3.5. $y \sin x$
15.3.6. no f
15.3.7. xyz
15.3.8. 6
15.3.9. $1/e - \sin 3$
15.3.10. $1/\sqrt{77} - \sqrt{3}$
15.4.1. 1
15.4.2. 0
15.4.3. $1/(2e) - 1/(2e^7) + e/2 - e^7/2$
15.4.4. $1/2$
15.4.5. $-1/6$
15.4.6. $(2\sqrt{3} - 10\sqrt{5} + 8\sqrt{6})/3 - 2\sqrt{2}/5 + 1/5$
15.4.7. $11/2 - \ln(2)$
15.4.8. $2 - \pi/2$
15.4.9. $-17/12$
15.4.10. 0
15.4.11. $-\pi/2$
15.4.12. 12π
15.5.1. $-1, 0$
15.5.2. $0, a + b$
15.5.3. $(2b - a)/3, 0$
15.5.4. $0, 1$
15.5.5. $-2\pi, 0$
15.5.6. $0, 2\pi$
15.6.1. $25\sqrt{21}/4$
15.6.2. $\pi\sqrt{21}$
15.6.3. $\pi(5\sqrt{5} - 1)/6$
15.6.4. $4\pi\sqrt{2}$
15.6.5. $\pi a^2/2$
15.6.6. $2\pi a(a - \sqrt{a^2 - b^2})$
15.6.7. $\pi((1 + 4a^2)^{3/2} - 1)/6$
15.6.8. $2\pi((1 + a^2)^{3/2} - 1)/3$
15.6.9. $\pi a^2 - 2a^2$
15.6.10. $\pi a^2 \sqrt{1 + k^2}/4$
15.6.11. $A\sqrt{1 + a^2 + b^2}$
15.6.12. $A\sqrt{k^2 + 1}$
15.6.13. $8a^2$
15.7.1. $(0, 0, 3/8)$
15.7.2. $(11/20, 11/20, 3/10)$
15.7.3. on center axis, $h/3$ above the base
15.7.4. 16
15.7.5. 7
15.7.6. $-\pi$
15.7.7. $-137/120$
15.7.8. $-2/e$
15.7.9. $\pi b^2(-4b^4 - 3b^2 + 6a^2b^2 + 6a^2)/6$
15.8.1. -3π
15.8.2. 0
15.8.3. -4π
15.8.4. $A(p(c - b) + q(a - c) + a - b)$
15.9.1. $a^2bc + ab^2c + abc^2$
15.9.2. $e^2 - 2e + 7/2$
15.9.3. 3
15.9.4. $384\pi/5$
15.9.5. $\pi/3$
15.9.6. 10π
15.9.7. $\pi/2$