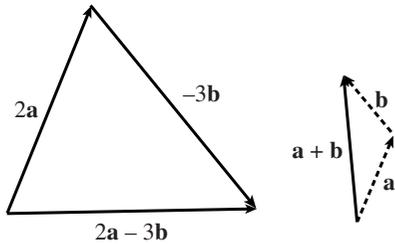
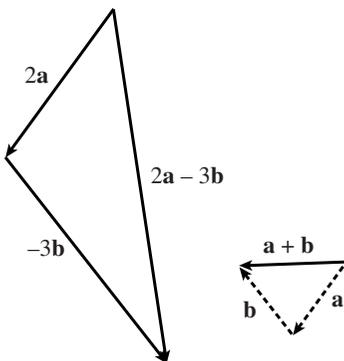


**CHAPTER 10**
**Exercises Section 10.1**

5.

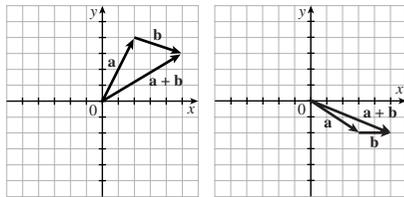


7.



9.  $\langle 5, 3 \rangle$ ,  $\langle -4, 6 \rangle$ ,  $\langle 6, 12 \rangle$ ,  $\sqrt{290}$   
 11.  $4\mathbf{i} + \mathbf{j}$ ,  $-5\mathbf{i} + 4\mathbf{j}$ ,  $3\mathbf{i} + 6\mathbf{j}$ ,  $5\sqrt{10}$   
 13.  $\langle -3, 3 \rangle$ ,  $\langle -4, 0 \rangle$ ,  $\langle -5, 9 \rangle$ ,  $4\sqrt{13}$   
 15.  $-2\mathbf{i} + 3\mathbf{j}$ ,  $-12\mathbf{i} + 4\mathbf{j}$ ,  $6\mathbf{i} + 5\mathbf{j}$ ,  $4\sqrt{5}$

17.

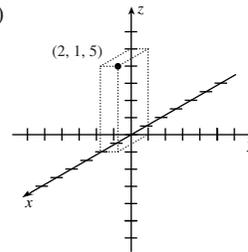


19. parallel    21. not    23. parallel    25. not  
 27.  $\langle 3, 1 \rangle$     29.  $\langle -3, -3 \rangle$     31.  $\langle 2, -3 \rangle$   
 33.  $\langle -2, -3 \rangle$     35. (a)  $\langle \frac{4}{5}, -\frac{3}{5} \rangle$  (b)  $5\langle \frac{4}{5}, -\frac{3}{5} \rangle$

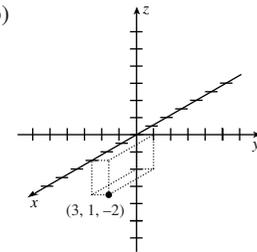
37. (a)  $\frac{1}{\sqrt{5}}\mathbf{i} - \frac{2}{\sqrt{5}}\mathbf{j}$  (b)  $2\sqrt{5}\langle \frac{1}{\sqrt{5}}, -\frac{2}{\sqrt{5}} \rangle$   
 39. (a)  $\mathbf{i}$  (b)  $4\langle 1, 0 \rangle$     41. (a)  $\langle \frac{3}{\sqrt{10}}, \frac{1}{\sqrt{10}} \rangle$   
 (b)  $\sqrt{10}\langle \frac{3}{\sqrt{10}}, \frac{1}{\sqrt{10}} \rangle$     43. (a)  $\langle -\frac{3}{5}, \frac{4}{5} \rangle$  (b)  $5\langle -\frac{3}{5}, \frac{4}{5} \rangle$   
 45.  $\frac{9}{5}\mathbf{i} + \frac{12}{5}\mathbf{j}$     47.  $\langle 2\sqrt{29}, 5\sqrt{29} \rangle$     49.  $\langle 4, 0 \rangle$   
 51. 10 pounds down, 20 pounds to the right  
 53. 190 pounds up, 30 pounds to the right  
 55.  $\langle 13, 17 \rangle$ ; right and up  
 57.  $\langle -80\sqrt{14}, 20 \rangle$  or  $3.8^\circ$  north of west  
 59.  $\langle 20, 20\sqrt{399} \rangle$  or  $2.9^\circ$  east of north    61. 10 feet  
 63.  $20\sqrt{101}$  pounds at  $5.7^\circ$     65. 7, 1, 5  
 69.  $\|\mathbf{a} + \mathbf{b}\| = \sqrt{58} < \sqrt{13} + \sqrt{17} = \|\mathbf{a}\| + \|\mathbf{b}\|$   
 71.  $\mathbf{a} = c\mathbf{b}$  ( $c > 0$ );  $\mathbf{a} \perp \mathbf{b}$ ;  $\|\mathbf{a} + \mathbf{b}\|^2 > \|\mathbf{a}\|^2 + \|\mathbf{b}\|^2$  when  $\mathbf{a} = c\mathbf{b}$  for  $c > 0$  or when the angle between  $\mathbf{a}$  and  $\mathbf{b}$  in the triangle formed by  $\mathbf{a}$ ,  $\mathbf{b}$ , and  $\mathbf{a} + \mathbf{b}$  is obtuse,  $\|\mathbf{a} + \mathbf{b}\|^2 < \|\mathbf{a}\|^2 + \|\mathbf{b}\|^2$  when  $\mathbf{a} = c\mathbf{b}$  for  $c < 0$  or when the angle between  $\mathbf{a}$  and  $\mathbf{b}$  in the triangle formed by  $\mathbf{a}$ ,  $\mathbf{b}$ , and  $\mathbf{a} + \mathbf{b}$  is acute,  $\|\mathbf{a} + \mathbf{b}\|^2 = \|\mathbf{a}\|^2 + \|\mathbf{b}\|^2$  when  $\mathbf{a} \perp \mathbf{b}$ .

**Exercises Section 10.2**

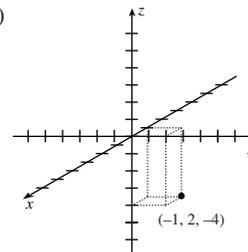
5. (a)



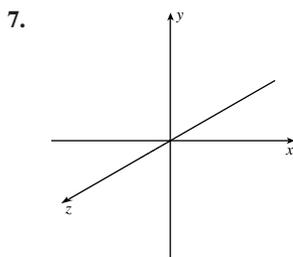
(b)



(c)



## 1236 Appendix B Answers to Odd-Numbered Exercises



9. 5    11. 3    13.  $\sqrt{38}$   
 15.  $(3, 4, -2)$ ,  $(-1, -8, -2)$ ,  $2\sqrt{66}$   
 17.  $(3, 3, 4)$ ,  $(-13, -9, -4)$ , 14  
 19.  $8\mathbf{i} + 4\mathbf{k}$ ,  $-12\mathbf{i} - 4\mathbf{j} + 4\mathbf{k}$ ,  $2\sqrt{186}$   
 21. (a)  $\pm \frac{1}{\sqrt{14}}(3, 1, 2)$  (b)  $\sqrt{14}\left\langle \frac{3}{\sqrt{14}}, \frac{1}{\sqrt{14}}, \frac{1}{\sqrt{14}} \right\rangle$   
 23. (a)  $\pm \frac{1}{\sqrt{14}}(1, -2, 3)$  (b)  $2\sqrt{14}\left\langle \frac{1}{\sqrt{14}}, -\frac{2}{\sqrt{14}}, \frac{3}{\sqrt{14}} \right\rangle$   
 25. (a)  $\pm \frac{1}{3}(2\mathbf{i} - \mathbf{j} + 2\mathbf{k})$  (b)  $3\left\langle \frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k} \right\rangle$   
 27. (a)  $\pm \frac{1}{\sqrt{2}}(1, 0, -1)$  (b)  $2\sqrt{2}\left\langle \frac{1}{\sqrt{2}}, 0, -\frac{1}{\sqrt{2}} \right\rangle$   
 29.  $(4, 4, -2)$     31.  $\frac{2}{\sqrt{5}}(2, 0, -1)$   
 33.  $\frac{4}{\sqrt{14}}(2\mathbf{i} - \mathbf{j} + 3\mathbf{k})$   
 35.  $(x - 3)^2 + (y - 1)^2 + (z - 4)^2 = 4$   
 37.  $(x - 2)^2 + y^2 + (z + 3)^2 = 9$   
 39.  $(x - \pi)^2 + (y - 1)^2 + (z + 3)^2 = 5$   
 41. sphere, center  $(1, 0, -2)$ , radius 2  
 43. sphere, center  $(0, 1, -2)$ , radius 3  
 45. sphere, center  $(1, 0, 2)$ , radius  $\sqrt{5}$   
 47. plane parallel to  $xz$ -plane    49. plane parallel to  $xy$ -plane  
 51. plane parallel to  $yz$ -plane    53.  $y = 0$     55.  $x = 0$   
 61.  $(2, -1, 1)$ ,  $(4, -2, 2)$ , yes  
 63. 1000 pounds up,  $\frac{150}{\sqrt{2}}$  pounds west,  $\frac{150}{\sqrt{2}}$  pounds south

## Exercises Section 10.3

5. 10    7. -8    9. -3    11. 10    13. 1  
 15.  $\cos^{-1} \frac{1}{\sqrt{26}} \approx 1.37$     17.  $\cos^{-1} \frac{-2}{\sqrt{10}} \approx 2.26$   
 19.  $\cos^{-1} \frac{-8}{\sqrt{234}} \approx 2.12$     21. yes    23. no    25. yes  
 27. possible answer:  $(1, 2)$     29. possible answer:  $(1, 4, 0)$   
 31. possible answer:  $\mathbf{j} + 2\mathbf{k}$     33.  $2, \left\langle \frac{6}{5}, \frac{8}{5} \right\rangle$   
 35.  $\frac{9}{5}, \frac{9}{25}(4\mathbf{i} - 3\mathbf{j})$     37.  $2, \frac{2}{3}(1, 2, 2)$   
 39.  $-\frac{8}{5}, -\frac{8}{25}(0, -3, 4)$   
 41. 105,600 foot-pounds    45. 920 foot-pounds  
 47. (a) false (b) true (c) true (d) false (e) false  
 49.  $\mathbf{a} = c\mathbf{b}$     53.  $\cos^{-1}\left(-\frac{1}{3}\right) \approx 109.5^\circ$

57.  $-\frac{200}{3\sqrt{14}} \approx -17.8$  Newtons  
 59. -347 pounds    61.  $\mathbf{v} \cdot \mathbf{n} = 0$ ,  $-w \sin \theta$ ,  $w \cos \theta$   
 63.  $45^\circ$     65. \$190,000; monthly revenue

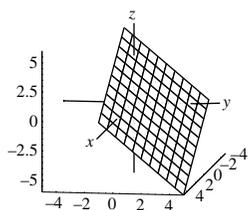
## Exercises Section 10.4

5. 1    7. 4    9.  $(4, -3, -2)$     11.  $(-9, -4, 1)$   
 13.  $(0, 4, 1)$     15.  $(4, -2, 8)$     17.  $\pm \frac{1}{\sqrt{69}}(8, 1, -2)$   
 19.  $\pm \frac{1}{\sqrt{46}}(-3, -6, 1)$     21.  $\pm \frac{1}{\sqrt{154}}(-1, -3, 12)$   
 23.  $\sin^{-1} \frac{7}{\sqrt{85}} \approx 0.86$     25.  $\sin^{-1} \frac{13}{\sqrt{170}} \approx 1.49$   
 27.  $\sqrt{\frac{7}{2}} \approx 1.87$     29.  $\sqrt{\frac{61}{5}} \approx 3.49$   
 31. 9.4 foot-pounds    33. 10 foot-pounds    35. up  
 37. left    39. down, left    41. down    43. ball rises  
 45. ball drops, moves left    47. ball drops    49. no effect  
 51. ball rises    53. ball rises, lands softly  
 55. ball rises, curves right    57. false    59. false  
 61. true    63. 5    65.  $\frac{11\sqrt{3}}{2}$     67. 10    69. 0  
 71.  $-\mathbf{i}$     73.  $-3\mathbf{j}$     75. yes    77. no

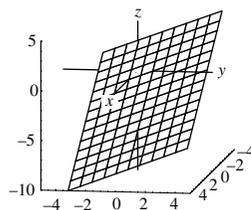
## Exercises Section 10.5

5. (a)  $x = 1 + 2t$ ,  $y = 2 - t$ ,  $z = -3 + 4t$   
 (b)  $\frac{x-1}{2} = \frac{y-2}{-1} = \frac{z+3}{4}$   
 7. (a)  $x = 2 + 2t$ ,  $y = 1 - t$ ,  $z = 3 + t$   
 (b)  $\frac{x-2}{2} = \frac{y-1}{-1} = \frac{z-3}{1}$   
 9. (a)  $x = 1 - 3t$ ,  $y = 4$ ,  $z = 1 + t$   
 (b)  $\frac{x-1}{-3} = \frac{z-1}{1}$ ,  $y = 4$   
 11. (a)  $x = 3 + 3t$ ,  $y = 1 - 4t$ ,  $z = -1 + 2t$   
 (b)  $\frac{x-3}{3} = \frac{y-1}{-4} = \frac{z+1}{2}$   
 13. (a)  $x = 2 - 4t$ ,  $y = -t$ ,  $z = 1 + 2t$   
 (b)  $\frac{x-2}{-4} = \frac{y}{-1} = \frac{z-1}{2}$   
 15. (a)  $x = 1 + 2t$ ,  $y = 2 - t$ ,  $z = -1 + 3t$   
 (b)  $\frac{x-1}{2} = \frac{y-2}{-1} = \frac{z+1}{3}$   
 17.  $\cos^{-1} \frac{-13}{\sqrt{234}} \approx 2.59$     19. perpendicular    21. parallel  
 23. intersect    25. parallel  
 27.  $2(x - 1) - (y - 3) + 5(z - 2) = 0$   
 29.  $-3(x + 2) + 2z = 0$   
 31.  $2(x - 2) - 7y - 3(z - 3) = 0$   
 33.  $2(x + 2) + 6(y - 2) - 3z = 0$   
 35.  $3(x - 2) - (y - 1) + 2(z + 1) = 0$   
 37.  $-2x + 4(y + 2) = 0$   
 39.  $(x - 1) - (y - 2) + (z - 1) = 0$

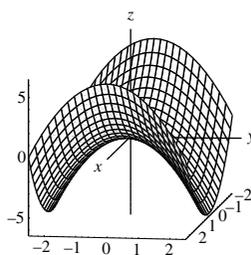
41.



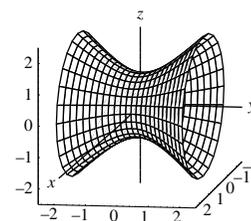
43.



13.



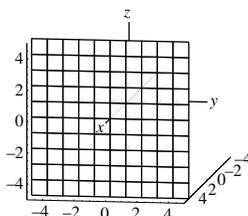
15.



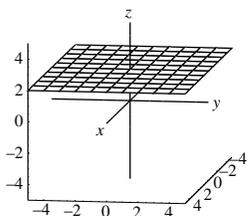
hyperboloid of 1 sheet

hyperbolic paraboloid

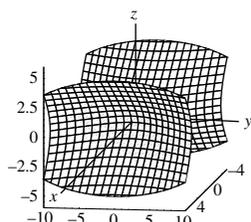
45.



47.

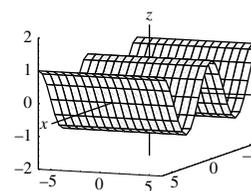


17.



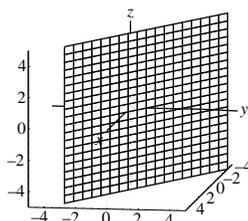
hyperboloid of 2 sheets

19.

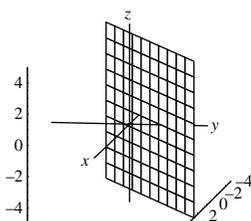


cylinder

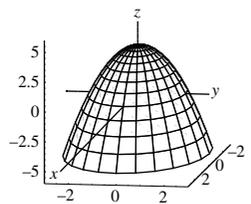
49.



51.

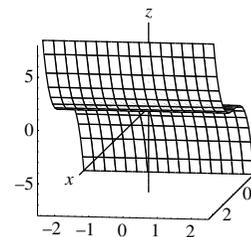


21.



circular paraboloid

23.



cylinder

53.  $x = t, y = \frac{5}{3}t - \frac{4}{3}, z = \frac{1}{3}t - \frac{8}{3}$

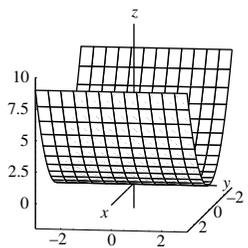
55.  $x = 4t + 11, y = -3t - 8, z = t$     57.  $\frac{2}{3}$     59.  $\frac{2}{\sqrt{3}}$

61.  $\frac{3}{\sqrt{6}}$     65.  $-4(x - 4) + 2(z - 3) = 0$

67. intersect at (3, 4, 4), collide if  $s = 1$  when  $t = 1$

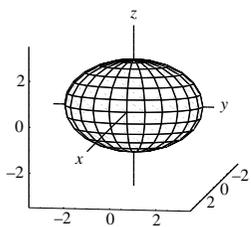
**Exercises Section 10.6**

5.



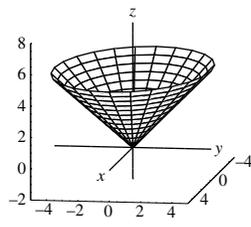
cylinder

7.



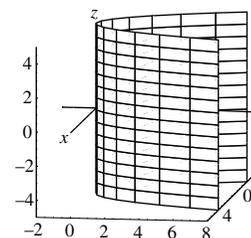
ellipsoid

25.



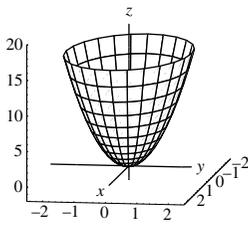
circular cone,  $z \geq 0$

27.



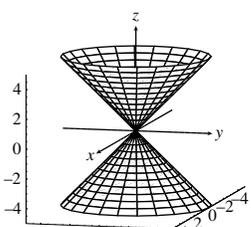
cylinder

9.



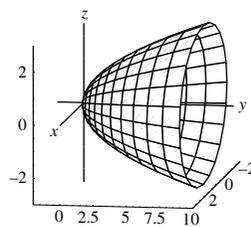
circular paraboloid

11.



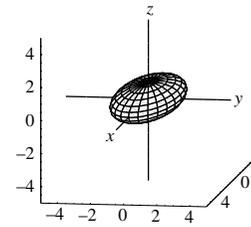
elliptic cone

29.



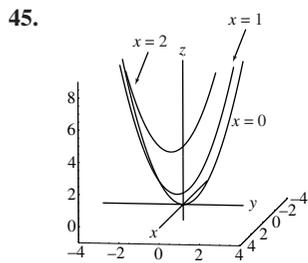
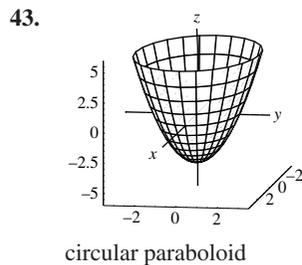
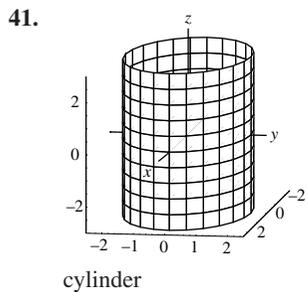
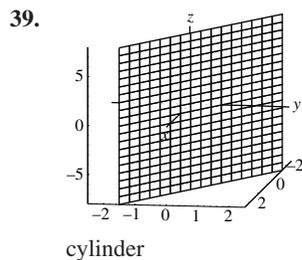
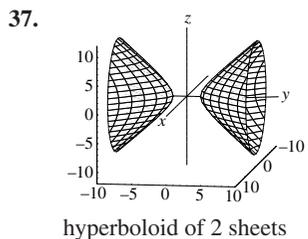
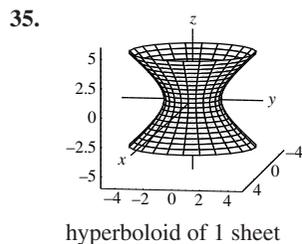
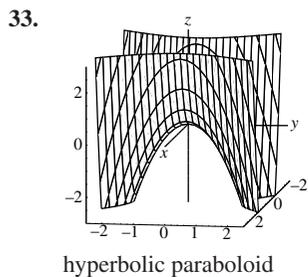
circular paraboloid

31.



ellipsoid

**1238 Appendix B** Answers to Odd-Numbered Exercises

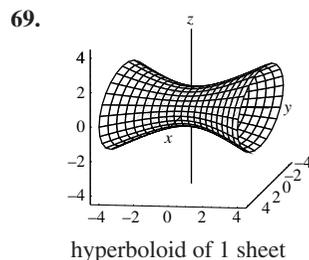
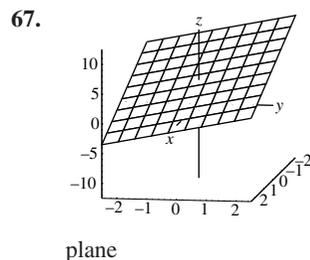
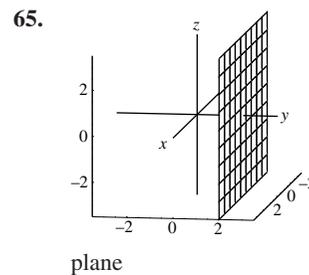
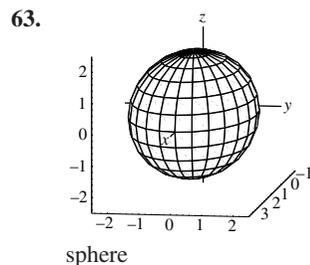
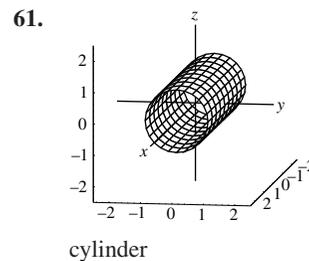
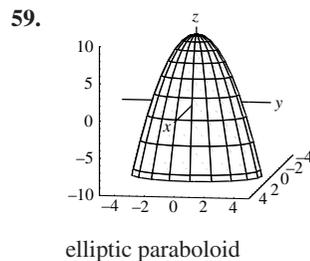


49.  $(0, 1, -1)$  and  $(0, -1, -1)$   
 57. exercise 7:  $x = \sin s \cos t, y = 3 \sin s \sin t, z = 2 \cos s$ ;  
 exercise 9:  $x = \frac{1}{2}s \cos t, y = \frac{1}{2}s \sin t, z = s^2$ ;  
 exercise 11:  $x = \frac{1}{2}\sqrt{s^2} \cos t, y = \sqrt{s^2} \sin t, z = s$   
 59. possible answer:  $x = s \cos t, y = s \sin t, z = 4 - s^2$

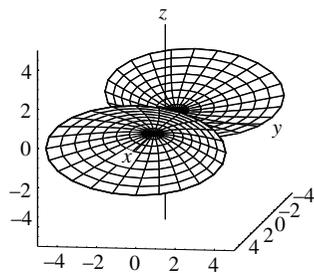
**Chapter 10 Review Exercises**

1.  $\langle -1, 3 \rangle, \langle 4, 0 \rangle, 5$     3.  $6\mathbf{i} + 5\mathbf{j}, -16\mathbf{i} + 12\mathbf{j} + 8\mathbf{k}, 2\sqrt{94}$   
 5. neither    7. parallel    9.  $\langle -1, -2, 3 \rangle$

11.  $\langle \frac{1}{\sqrt{5}}, \frac{2}{\sqrt{5}} \rangle$     13.  $\frac{1}{3\sqrt{3}}(5\mathbf{i} + \mathbf{j} - \mathbf{k})$   
 15.  $\langle -\frac{3}{5}, 0, \frac{4}{5} \rangle$     17.  $\sqrt{46}$     19.  $\frac{2}{\sqrt{3}}(\mathbf{i} - \mathbf{j} + \mathbf{k})$   
 21.  $(20\sqrt{609}, 80)$  or  $9.2^\circ$  north of east  
 23.  $x^2 + (y + 2)^2 + z^2 = 36$     25. 0    27. -8  
 29.  $\cos^{-1} \frac{1}{\sqrt{84}} \approx 1.46$     31.  $\frac{1}{\sqrt{6}}, \frac{1}{6}(\mathbf{i} + 2\mathbf{j} + \mathbf{k})$   
 33.  $\langle -2, 1, 4 \rangle$     35.  $-4\mathbf{i} + 4\mathbf{j} - 8\mathbf{k}$   
 37.  $\pm \frac{1}{\sqrt{21}} \langle -2, 1, 4 \rangle$     39. 1700 foot-pounds    41. 3  
 43.  $\sqrt{41}$     45.  $\frac{25}{2}$  foot-pounds  
 47. (a)  $x = 2 - 2t, y = -1 + 3t, z = -3$   
 (b)  $\frac{x-2}{-2} = \frac{y+1}{3}, z = -3$   
 49. (a)  $x = 2 + 2t, y = -1 + \frac{1}{2}t, z = 1 - 3t$   
 (b)  $\frac{x-2}{2} = 2(y+1) = \frac{z-1}{-3}$   
 51.  $\cos^{-1} \frac{5}{\sqrt{30}} \approx 0.42$     53. skew  
 55.  $4(x + 5) + y - 2(z - 1) = 0$   
 57.  $4(x - 2) - (y - 1) + 2(z - 3) = 0$



71.

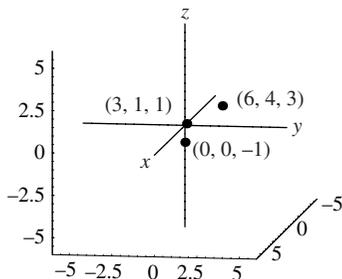


hyperboloid of 2 sheets

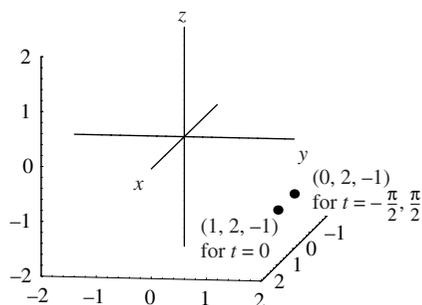
**CHAPTER 11**

**Exercises Section 11.1**

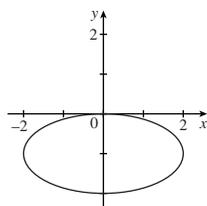
5.



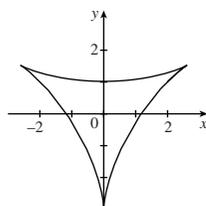
7.



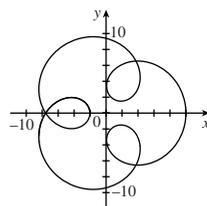
9.



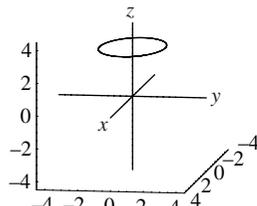
11.



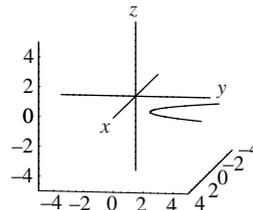
13.



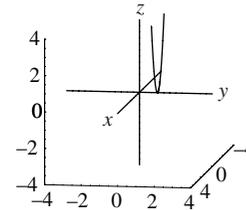
15.



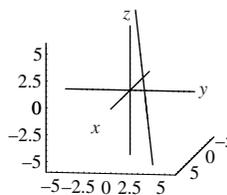
17.



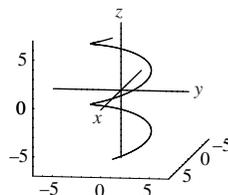
19.



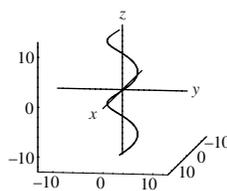
21.



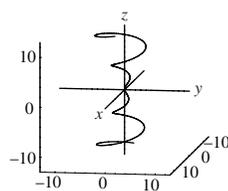
23.



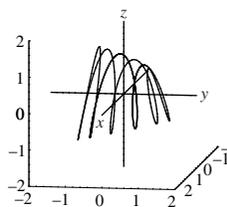
25.



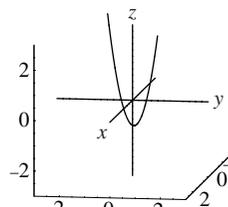
27.



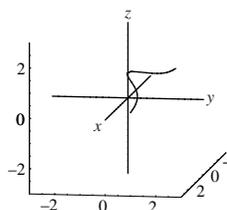
29.



31.



33.



35. (a) F (b) C (c) E (d) A (e) B (f) D

37. 10.54 39. 21.56 41. 9.57

43.  $\cos 2t = \cos^2 t - \sin^2 t$

47. same except  $-\infty < x < \infty, -1 \leq x \leq 1, 0 \leq x$

49. periodic, not enough points

**Exercises Section 11.2**

5.  $(-1, 1, 0)$  7.  $(1, 1, -1)$  9. does not exist

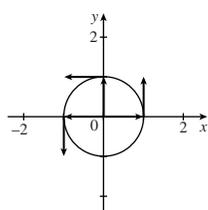
11.  $t \neq 1$  13.  $t \neq \frac{n\pi}{2}$  ( $n$  odd) 15.  $t \geq 0$

17.  $\left\langle 4t^3, \frac{1}{2\sqrt{t+1}}, -\frac{6}{t^3} \right\rangle$  19.  $\langle \cos t, 2t \cos t^2, -\sin t \rangle$

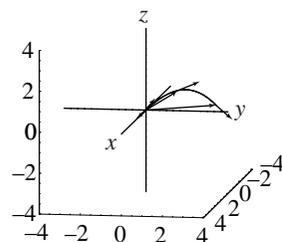
**1240 Appendix B** Answers to Odd-Numbered Exercises

21.  $\langle 2te^t, 2t, 2 \sec 2t \tan 2t \rangle$

23.



25.



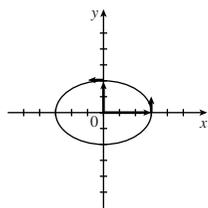
27.  $\langle \frac{3}{2}t^2 - t, \frac{2}{3}t^{3/2} \rangle + \mathbf{c}$     29.  $\langle \frac{1}{3} \sin 3t, -\cos t, \frac{1}{4}e^{4t} \rangle + \mathbf{c}$   
 31.  $\langle \frac{1}{2}e^t, 3 \sin t - 3t \cos t, \frac{3}{2} \ln(t^2 + 1) \rangle + \mathbf{c}$   
 33.  $\langle -\frac{2}{3}, \frac{3}{2} \rangle$     35.  $\langle 4 \ln 3, 1 - e^{-2}, e^2 + 1 \rangle$     37. all  $t$   
 39.  $t = 0$     43.  $t = 0$     45.  $t = \frac{n\pi}{4}$  ( $n$  odd)    51. false

**Exercises Section 11.3**

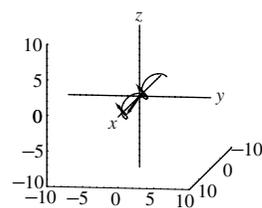
- 5.
- $\langle -10 \sin 2t, 10 \cos 2t \rangle, \langle -20 \cos 2t, -20 \sin 2t \rangle$
- 
- 7.
- $\langle 25, -32t + 15 \rangle, \langle 0, -32 \rangle$
- 
- 9.
- $\langle (4 - 8t)e^{-2t}, -4e^{-2t}, -32t \rangle, \langle (-16 + 16t)e^{-2t}, 8e^{-2t}, -32 \rangle$
- 
- 11.
- $\langle 10t + 3, -16t^2 + 4t + 8 \rangle$
- 13.
- $\langle 5t, -16t^2 + 16 \rangle$
- 
- 15.
- $\langle 10t, -3e^{-t} - 3, -16t^2 + 4t + 20 \rangle$
- 
- 17.
- $\langle \frac{1}{6}t^3 + 12t + 5, -4t, -8t^2 + 2 \rangle$
- 
- 19.
- $\langle -160 \cos 2t, \sin 2t \rangle$
- 21.
- $\langle -960 \cos 4t, \sin 4t \rangle$
- 
- 23.
- $\langle -120 \cos 2t, -200 \sin 2t \rangle$
- 25.
- $\langle 60, 0 \rangle$
- 
- 27.
- $\frac{1875}{16} \approx 117$
- feet,
- $\frac{625\sqrt{3}}{4} \approx 271$
- feet, 100 ft/s
- 
29. 210 feet,
- $400 + 40\sqrt{105} \approx 810$
- feet,
- $8\sqrt{410} \approx 162$
- ft/s
- 
31. 810 feet,
- $1600 + 720\sqrt{5} \approx 3210$
- feet,
- $8\sqrt{1610} \approx 321$
- ft/s
- 
33. quadruples    37.
- $\langle 60\sqrt{3}t, 3 + 60t - 16t^2 \rangle, \text{no}$
- 
- 39.
- $\langle 130t, 6 - 16t^2 \rangle, 2.59$
- feet    41.
- $\langle 120t, 8 - 16t^2 \rangle, \text{no}$
- 
43. 3.86 sec    45.
- $\langle 271, 117, 0 \rangle$
- 
- 47.
- $a = 100, b = -1, c = 10$
49. 56.57 ft/s
- 
51. 1275.5 m

**Exercises Section 11.4**

- 5.
- $x = 2 \cos(\frac{s}{2}), y = 2 \sin(\frac{s}{2}), 0 \leq s \leq 4\pi$
- 
- 7.
- $x = \frac{3}{5}s, y = \frac{4}{5}s, 0 \leq s \leq 5$
- 
- 9.
- $\langle 1, 0 \rangle, \frac{1}{\sqrt{13}} \langle 3, -2 \rangle, \frac{1}{\sqrt{13}} \langle 3, 2 \rangle$
- 
- 11.
- $\langle 0, 1 \rangle, \langle 1, 0 \rangle, \langle -1, 0 \rangle$
- 
- 13.
- $\frac{1}{\sqrt{13}} \langle 3, 0, 2 \rangle, \frac{1}{\sqrt{13}} \langle 3, 0, 2 \rangle, \frac{1}{\sqrt{13}} \langle 3, 0, 2 \rangle$
- 
- 15.



17.



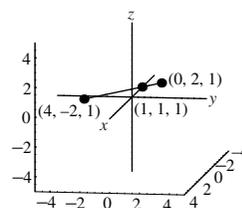
- 19.
- $2^{-3/2} \approx 0.3536$
21. 0    23.
- $6(37)^{-3/2} \approx 0.0267$
- 
25. 1    27. smaller    29.
- $\frac{8}{25}, \frac{8}{25}$
- 31.
- $1, \frac{1}{27}$
- 
33. max at
- $\langle 0, \pm 3 \rangle$
- , min at
- $\langle \pm 2, 0 \rangle$
- 
35. max at
- $\langle 0, -3 \rangle$
- , no min    37. 0    39. 0
- 
41. curve straightens    43. false    45. true    49.
- $\frac{2}{3}, 10$
- 
- 51.
- $\frac{1}{\sqrt{45}}, \frac{1}{\sqrt{45}}e^{-2}$
- 53.
- $\frac{25}{52} > \frac{1}{10}$

**Exercises Section 11.5**

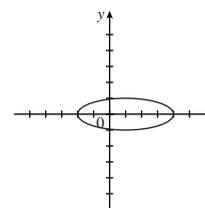
- 5.
- $\langle 1, 0 \rangle$
- and
- $\langle 0, 1 \rangle, \frac{1}{\sqrt{5}} \langle 1, 2 \rangle$
- and
- $\frac{1}{\sqrt{5}} \langle -2, 1 \rangle$
- 
- 7.
- $\langle 0, 1 \rangle$
- and
- $\langle -1, 0 \rangle, \langle -1, 0 \rangle$
- and
- $\langle 0, -1 \rangle$
- 
- 9.
- $\frac{1}{\sqrt{5}} \langle 0, 1, 2 \rangle$
- and
- $\langle -1, 0, 0 \rangle, \frac{1}{\sqrt{5}} \langle 0, 1, -2 \rangle$
- and
- $\langle 1, 0, 0 \rangle$
- 
- 11.
- $\frac{1}{\sqrt{2}} \langle 1, 0, 1 \rangle$
- and
- $\langle 0, 1, 0 \rangle,$
- 
- $\frac{1}{\sqrt{6}} \langle 1, 2, 1 \rangle$
- and
- $\frac{1}{\sqrt{3}} \langle -1, 1, -1 \rangle$
- 
- 13.
- $x^2 + (y - \frac{1}{2})^2 = \frac{1}{4}$
- 15.
- $x^2 + y^2 = 1$
- 
- 17.
- $a_T = -\frac{64}{\sqrt{5}}$
- and
- $a_N = \frac{32}{\sqrt{5}}, a_T = \frac{64}{\sqrt{5}}$
- and
- $a_N = \frac{32}{\sqrt{5}}$
- 
- 19.
- $a_T = 0$
- and
- $a_N = \sqrt{20},$
- 
- $a_T = \frac{2\pi}{\sqrt{16 + \pi^2}}$
- and
- $a_N = 4\sqrt{\frac{20 + \pi^2}{16 + \pi^2}}$
- 
21. neither; increasing    23.
- $a_T = 0$
- and
- $a_N = a$
- 
- 25.
- $\frac{1}{\sqrt{5}} \langle 2, -1, 0 \rangle, \frac{1}{\sqrt{5}} \langle 2, -1, 0 \rangle$
- 
- 27.
- $\frac{1}{\sqrt{1 + 16\pi^2}} \langle 0, -1, 4\pi \rangle, \frac{1}{\sqrt{1 + 16\pi^2}} \langle 0, 1, 4\pi \rangle$
- 
29. true    31. true    33.
- $10,000\pi^2 \langle -\cos \pi t, -\sin \pi t \rangle$
- 
- 35.
- $40,000\pi^2 \langle -\cos 2\pi t, -\sin 2\pi t \rangle$
37. doubles
- 
- 39.
- $1 < \frac{3\sqrt{3}}{2}, |-1| > \left| -\frac{1}{\sqrt{2}} \right|$

**Chapter 11 Review Exercises**

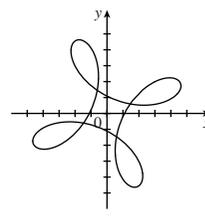
1.



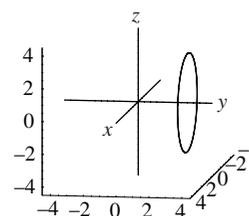
3.



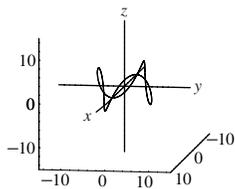
5.



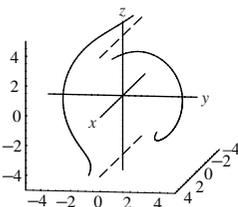
7.



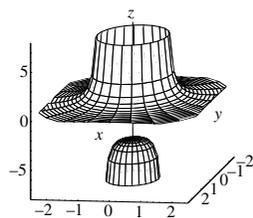
9.



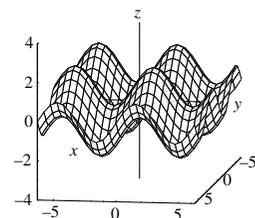
11.



27.



29.



13. (a) B (b) C (c) A (d) F (e) D (f) E

15.  $2\pi\sqrt{37}$  17.  $(0, e^2, -1)$  19.  $t \neq 0$

21.  $\left\langle \frac{t}{\sqrt{t^2+1}}, 4 \cos 4t, \frac{1}{t} \right\rangle$

23.  $\left\langle -\frac{1}{4}e^{-4t}, -t^{-2}, 2t^2 - t \right\rangle + \mathbf{c}$  25.  $(0, 2, 2)$

27.  $\langle -8 \sin 2t, 8 \cos 2t, 4 \rangle, \langle -16 \cos 2t, -16 \sin 2t, 0 \rangle$

29.  $\langle t^2 + 4t + 2, -16t^2 + 1 \rangle$

31.  $\langle 4t + 2, -16t^2 + 3t + 6 \rangle$

33.  $(0, -128)$

35.  $25(2 - \sqrt{3}) \approx 6.70$  feet, 100 feet, 80 ft/s

37.  $\frac{1}{\sqrt{2}}\langle -1, 1, 0 \rangle, \frac{1}{\sqrt{e^{-4}+1}}\langle -e^{-2}, 1, 0 \rangle$

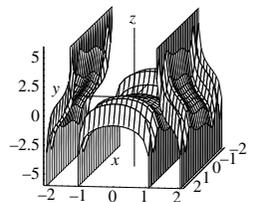
39.  $\frac{1}{2}, \frac{4}{3\sqrt{3}}$  41. 0, 0

43.  $\frac{1}{\sqrt{2}}\langle 0, 1, 1 \rangle, \langle -1, 0, 0 \rangle$

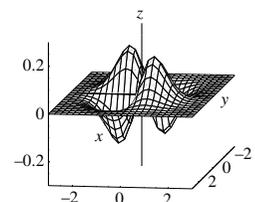
45.  $a_T = 0, a_N = 2; a_T = \sqrt{2}, a_N = \sqrt{2}$

47.  $345,600\langle -\cos 6t, -\sin 6t \rangle$

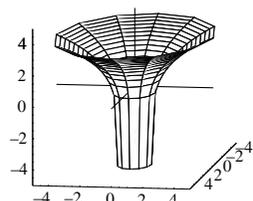
31.



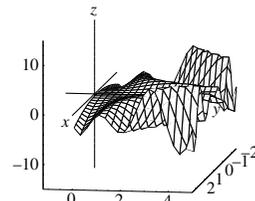
33.



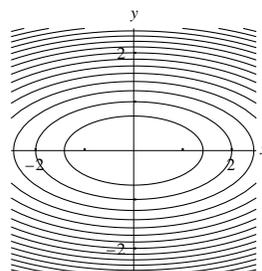
35.



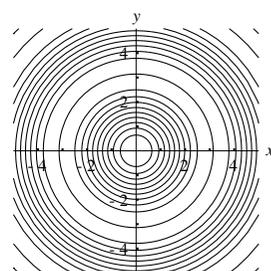
37.



39.



41.



## CHAPTER 12

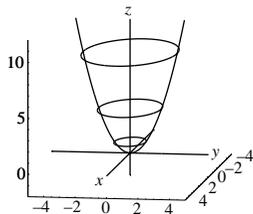
### Exercises Section 12.1

5.  $y \neq -x$  7.  $x + y + 2 > 0$  9.  $f \geq 0$

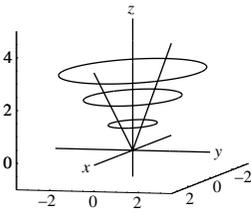
11.  $-1 \leq f \leq 1$  13.  $f \geq -1$  15. 3, 3

17. (a) 312 (b) 333 (c) 350 (d) 19 feet

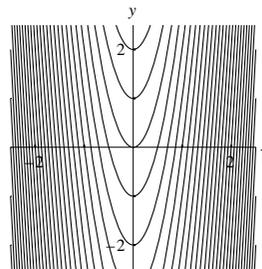
19.



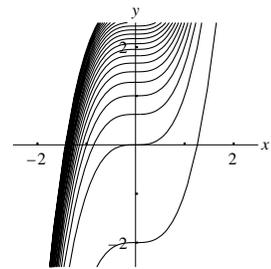
21.



43.

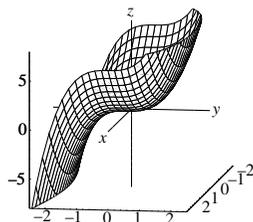


45.

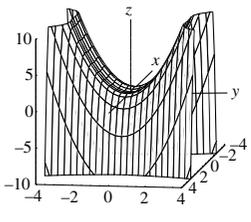


For 23–37, one view is shown.

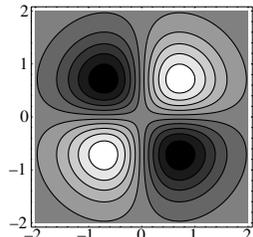
23.



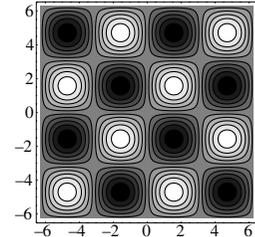
25.



47.



49.

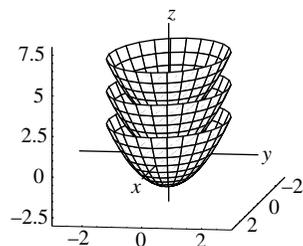


## 1242 Appendix B Answers to Odd-Numbered Exercises

51. (a) B (b) D (c) A (d) F (e) C (f) E

53. (a) A (b) D (c) C (d) B

55.



57. (a) B (b) A

59. no height visible 63. any point on the line  $(x, \sqrt{3}x, 0)$ 

65. upper left, restaurants, roads

67. left of center, power is increasing away from frame

69. max = 3.942, min = -0.57, HS

71. 60 mph, impossible

## Exercises Section 12.2

5. 3 7.  $-\frac{1}{2}$  9. 211. Along  $x = 0$ ,  $L_1 = 0$ ; along  $y = 0$ ,  $L_2 = 3$ , therefore  $L$  does not exist.13. Along  $x = 0$ ,  $L_1 = 0$ ; along  $y = x$ ,  $L_2 = 2$ , therefore  $L$  does not exist.15. Along  $x = 0$ ,  $L_1 = 0$ ; along  $x = y^2$ ,  $L_2 = 1$ , therefore  $L$  does not exist.17. Along  $x = 0$ ,  $L_1 = 0$ ; along  $y^3 = x$ ,  $L_2 = \frac{1}{2}$ , therefore  $L$  does not exist.19. Along  $x = 0$ ,  $L_1 = 0$ ; along  $y = x$ ,  $L_2 = \frac{1}{2}$ , therefore  $L$  does not exist.21. Along  $x = 1$ ,  $L_1 = 0$ ; along  $y = x + 1$ ,  $L_2 = \frac{1}{2}$ , therefore  $L$  does not exist.23. Along  $x = 0$ ,  $L_1 = 0$ ; along  $x^2 = y^2 + z^2$ ,  $L_2 = \frac{3}{2}$ , therefore  $L$  does not exist.25. Along  $y = -x$ ,  $L_1$  does not exist, therefore  $L$  does not exist.

27. 0 29. 0 31. 2 33. 0

39. all  $x, y$  41.  $x^2 + y^2 \leq 9$  43.  $x^2 - y < 3$ 45.  $y \neq 0$  47.  $x^2 + y^2 + z^2 \geq 4$  49.  $\frac{1}{2}$  51. true

53. false 57. 1 59. 0

## Exercises Section 12.3

5.  $f_x = 3x^2 - 4y^2$ ,  $f_y = -8xy + 4y^3$

7.  $f_x = 2xe^y$ ,  $f_y = x^2e^y - 4$

9.  $f_x = 2x \sin xy + x^2y \cos xy$ ,  $f_y = x^3 \cos xy - 9y^2$

11.  $f_x = \frac{4}{y}e^{x/y} + \frac{y}{x^2}$ ,  $f_y = -\frac{4x}{y^2}e^{x/y} - \frac{1}{x}$

13.  $f_x = 3 \sin y + 12x^2y^2z$ ,  $f_y = 3x \cos y + 8x^3yz$ ,  $f_z = 4x^3y^2$

15.  $f_x = \frac{-2x}{(x^2 + y^2 + z^2)^{3/2}}$ ,  $f_y = \frac{-2y}{(x^2 + y^2 + z^2)^{3/2}}$ ,

$$f_z = \frac{-2z}{(x^2 + y^2 + z^2)^{3/2}}$$

17.  $\frac{\partial^2 f}{\partial x^2} = 6x$ ,  $\frac{\partial^2 f}{\partial y^2} = -8x$ ,  $\frac{\partial^2 f}{\partial y \partial x} = -8y$

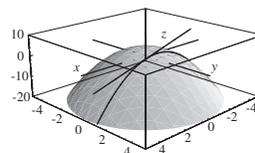
19.  $f_{xx} = 12x^2 - 6y^3$ ,  $f_{xy} = -18xy^2$ ,  $f_{xyy} = -36xy$

21.  $f_{xx} = 6xy^2$ ,  $f_{yz} = -\cos yz + yz \sin yz$ ,  $f_{xyz} = 0$

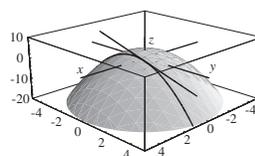
23.  $f_{xx} = 4y^2e^{2xy}$ ,  $f_{yy} = 4x^2e^{2xy} - \frac{2z^2}{y^3} - xz \sin y$ ,  
 $f_{yyzz} = -\frac{4}{y^3}$

25.  $f_{ww} = 2xy - z^2e^{wz}$ ,  $f_{wxy} = 2w$ ,  $f_{wxyz} = 0$

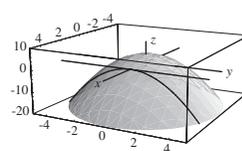
27.



29.



31.



33.  $\frac{nRV^3}{PV^3 - n^2aV + 2n^3ab}$  Hint: Hold pressure constant.

37.  $h$  39.  $(0, 0, 0) = \min$ 41.  $(\frac{m\pi}{2}, \frac{n\pi}{2}, 1) = \max$  for  $m, n$  odd; $(\frac{m\pi}{2}, \frac{n\pi}{2}, -1) = \min$  for  $m, n$  odd; $(m\pi, n\pi, 0)$  neither max nor min43. 4, 2 45.  $1, -\frac{2}{3}$  47. 1.4, -2.4

49. 2.2, 0.0195

53.  $\frac{\partial^2 f}{\partial x^2} = -n^2\pi^2 \sin n\pi x \cos n\pi ct$ ,

$$\frac{\partial^2 f}{\partial t^2} = -c^2n^2\pi^2 \sin n\pi x \cos n\pi ct$$

55.  $-\frac{5}{1+I}V$ ,  $-\frac{0.5}{1+0.1(1-T)}V$ , inflation

57.  $\cos x \cos t$ ,  $-\sin x \sin t$  61.  $(\frac{R}{R_1})^2$

63. 400,  $\frac{1}{4}$ , decrease by 2767. concavity of intersection of  $z = f(x, y)$  with  $y = y_0$  at  $x = x_0$ 

## Exercises Section 12.4

5.  $4(x-2) + 2(y-1) - (z-4) = 0$  7.  $z = 1$

9.  $-x - z = 0$  11.  $6(x+2) + 4(y-3) - (z-4) = 0$

13.  $-\frac{3}{5}(x+3) + \frac{4}{5}(y-4) - (z-5) = 0$

15.  $2(x-1) - (y-2) - (z-2) = 0$     17.  $x$   
 19.  $-x$     21.  $-3x$     23.  $-8 + 12(x+2) + y - 8(z-1)$   
 25.  $11 - 12(w+2) + 4(x-3) + 12(y-1) + 2z$   
 27. 3 vs. 3.0017, 3.1 vs. 3.1, 3.1 vs. 3.1016  
 29. 0 vs. 0,  $-0.1$  vs.  $-0.0998$ ,  $-0.1$  vs.  $-0.0988$   
 31.  $1.5552 \pm 0.6307$     33. 3.85    35. 4.03  
 37.  $2y\Delta x + (2x+2y)\Delta y + (2\Delta y)\Delta x + (\Delta y)\Delta y$   
 39.  $2x\Delta x + 2y\Delta y + (\Delta x)\Delta x + (\Delta y)\Delta y$   
 41. yes    43.  $(ye^x + \cos x) dx + e^x dy$   
 45.  $f_x(0,0) = f_y(0,0) = 0$     49.  $6 + 4x + 2y$   
 51.  $3 + x - \frac{2}{3}y$   
 53.  $-9 + 1.4(t-10) - 2.4(s-10)$ ;  $-13.4$

### Exercises Section 12.5

5.  $(2t + t^2 + 1 - \cos e^t)e^t$   
 7.  $\frac{\partial g}{\partial u} = 512u^6(3u^2 - v \cos u)(u^3 - v \sin u)$   
 $+ 1536u^5(u^3 - v \sin u)^2$ ;  
 $\frac{\partial g}{\partial v} = 512u^6 \sin u(v \sin u - u^3)$   
 9.  $g'(t) = \frac{\partial f}{\partial x}x'(t) + \frac{\partial f}{\partial y}y'(t) + \frac{\partial f}{\partial z}z'(t)$   
 11.  $\frac{\partial g}{\partial u} = \frac{\partial f}{\partial x} \frac{\partial x}{\partial u} + \frac{\partial f}{\partial y} \frac{\partial y}{\partial u}$ ,  $\frac{\partial g}{\partial v} = \frac{\partial f}{\partial x} \frac{\partial x}{\partial v} + \frac{\partial f}{\partial y} \frac{\partial y}{\partial v}$ ,  
 $\frac{\partial g}{\partial w} = \frac{\partial f}{\partial x} \frac{\partial x}{\partial w} + \frac{\partial f}{\partial y} \frac{\partial y}{\partial w}$   
 13.  $-0.6271$     15. 0.0587  
 19.  $\frac{\partial^2 f}{\partial x^2}[x'(t)]^2 + 2 \frac{\partial^2 f}{\partial y \partial x}x'(t)y'(t) + \frac{\partial^2 f}{\partial y^2}[y'(t)]^2$   
 $+ \frac{\partial f}{\partial x}x''(t) + \frac{\partial f}{\partial y}y''(t)$   
 21.  $\frac{\partial^2 f}{\partial x^2} \left(\frac{\partial x}{\partial u}\right)^2 + \frac{\partial^2 f}{\partial y \partial x} \frac{\partial y}{\partial u} \frac{\partial x}{\partial u} + \frac{\partial f}{\partial x} \frac{\partial^2 x}{\partial u^2}$   
 $+ \frac{\partial^2 f}{\partial x \partial y} \frac{\partial x}{\partial u} \frac{\partial y}{\partial u} + \frac{\partial^2 f}{\partial y^2} \left(\frac{\partial y}{\partial u}\right)^2 + \frac{\partial f}{\partial y} \frac{\partial^2 y}{\partial u^2}$   
 23.  $\frac{\partial z}{\partial x} = \frac{-6xz}{3x^2 + 6z^2 - 3y}$ ,  $\frac{\partial z}{\partial y} = \frac{3z}{3x^2 + 6z^2 - 3y}$   
 25.  $\frac{\partial z}{\partial x} = \frac{3yz e^{xyz} - 4z^2 + \cos y}{8xz - 3xy e^{xyz}}$ ,  $\frac{\partial z}{\partial y} = \frac{3xz e^{xyz} - x \sin y}{8xz - 3xy e^{xyz}}$   
 31. 2 points; halved

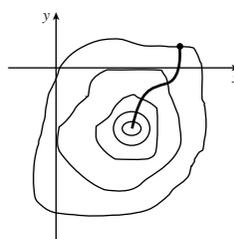
### Exercises Section 12.6

5.  $(2x + 4y^2, 8xy - 5y^4)$   
 7.  $(e^{xy^2} + xy^2 e^{xy^2}, 2x^2 y e^{xy^2} - 2y \sin y^2)$   
 9.  $(-8e^{-8} - 2, -16e^{-8})$     11.  $(\frac{4}{5}, -\frac{3}{5})$     13.  $(0, 0, -1)$   
 15.  $2 + 6\sqrt{3}$     17.  $2 - 6\sqrt{3}$     19.  $\frac{17}{5\sqrt{13}}$     21.  $-3\sqrt{5}$

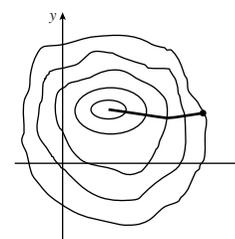
23. 0    25.  $-\frac{6}{\sqrt{5}}$     27.  $-\frac{12}{\sqrt{5}}$     29.  $-\frac{3}{\sqrt{29}}$   
 31.  $(4, -3), (-4, 3), 5, -5$   
 33.  $(16, -4), (-16, 4), \sqrt{272}, -\sqrt{272}$   
 35.  $(1, 0), (-1, 0), 1, -1$   
 37.  $(\frac{3}{2}, -\frac{1}{8}), (-\frac{3}{2}, \frac{1}{8}), \frac{\sqrt{145}}{8}, -\frac{\sqrt{145}}{8}$   
 39.  $(16, 4, 24), (-16, -4, -24), \sqrt{848}, -\sqrt{848}$   
 41. parallel  
 45.  $2(x-1) + 3(y+1) - z = 0$ ,  
 The equation of the normal line is  $\left. \begin{aligned} x &= 1 + 2t \\ y &= -1 + 3t \\ z &= -t \end{aligned} \right\}$   
 47.  $-2(x+1) + 4(y-2) + 2(z-1) = 0$ ,  
 The equation of the normal line is  $\left. \begin{aligned} x &= -1 - 2t \\ y &= 2 + 4t \\ z &= 1 + 2t \end{aligned} \right\}$

49.  $(0, 0, 0), (1, 1, -1), (-1, -1, -1)$

51.



53.



55. possible answer:  $(-\frac{4}{3}, -2)$     57.  $(2, -2)$   
 59.  $(-\tan 10^\circ, \tan 6^\circ) \approx (-0.176, 0.105)$ ,  $11.6^\circ$     61.  $(8, 4)$   
 63.  $(10e^{-8}, \frac{5}{16}e^{-8}, \frac{25}{4}e^{-8})$     65.  $(0.8, 0.3, -0.004)$   
 67.  $6x + 2$

### Exercises Section 12.7

5.  $(0, 0)$  saddle    7.  $(0, 0)$  saddle,  $(1, 1)$  relative min  
 9.  $(0, 1)$  relative min,  $(\pm 2, -1)$  saddle  
 11.  $(0, 0)$  max  
 13.  $(0, 0)$  saddle,  $(1, 1)$  and  $(-1, -1)$  relative min  
 15.  $(\frac{1}{\sqrt{2}}, 0)$  local max,  $(-\frac{1}{\sqrt{2}}, 0)$  local min  
 17.  $(0, 0)$  saddle,  $\pm(\sqrt{\frac{1}{2}}, \sqrt{\frac{1}{2}})$  relative max,  
 $\pm(\sqrt{\frac{1}{2}}, -\sqrt{\frac{1}{2}})$  relative min  
 19.  $(2.82, 0.17)$  relative min,  $(-2.84, -0.18)$  saddle,  
 $(0.51, 0.99)$  saddle  
 21.  $(\pm 1, 0)$  relative max,  $(0, -\sqrt{\frac{3}{2}})$  relative max,  $(0, \sqrt{\frac{3}{2}})$   
 relative min,  $(0, 0)$  saddle,  $(\pm \frac{\sqrt{19}}{3\sqrt{3}}, -\frac{2}{3})$  saddle  
 23.  $1.37x - 2.80$     25. 9176    27. 247, 104

## 1244 Appendix B Answers to Odd-Numbered Exercises

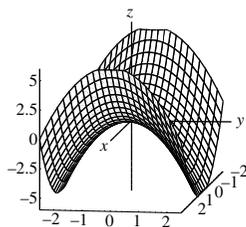
29. (a) 1.29 (b) 2.75  
 31.  $(-0.3210, -0.5185), (-0.1835, -0.4269)$   
 33.  $(0.9044, 0.8087), (3.2924, -0.3853)$   
 35.  $(0, 0)$  is a saddle point  
 37.  $f(2, 0) = 4, f(2, 2) = -2$   
 39.  $f(3, 0) = 9, f(0, 0) = 0$   
 41.  $f(0, y) = f(x, 0) = 0$  min  
 43.  $f(-1, 2) = -4$  min    51. false    53. false  
 55. extrema at  $(\pm \frac{\pi}{2}, \pm \frac{\pi}{2})$ , saddles at  $(\pm n\pi, \pm n\pi)$   
 57. extrema at  $\pm(1, 1)$ , saddle  $(0, 0)$   
 59. extrema  $(\pm 0.1, 0.1)$ , saddle  $(0, 0)$   
 61.  $d(x, y) = \sqrt{(x-3)^2 + (y+2)^2 + (3-x^2-y^2)^2}$ ,  
 $(1.55, -1.03)$   
 63.  $(1.6, 0.8, -2.4)$     65.  $(1, 0), f(1, 0) < f(-10, 0)$

## Exercises Section 12.8

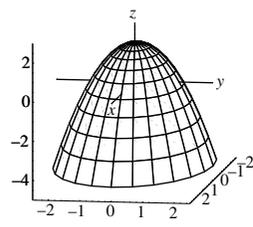
5.  $x = \frac{6}{5}, y = -\frac{2}{5}$     7.  $x = 2, y = -1$   
 9.  $x = 1, y = 1$     11.  $x = 1, y = 1$   
 13. max =  $f(2, 2) = f(-2, -2) = 16$ ,  
 min =  $f(2, -2) = f(-2, 2) = -16$   
 15. max =  $f(\pm\sqrt{2}, 1) = 8$ , min =  $f(\pm\sqrt{2}, -1) = -8$   
 17. max =  $f(1, 1) = e$ , min =  $f(-1, 1) = -e$   
 19. max =  $f(\pm\sqrt{2}, 1) = 2e$ , min =  $f(0, \pm\sqrt{3}) = 0$   
 21. max =  $f(2, 2) = f(-2, -2) = 16$   
 min =  $f(2, -2) = f(-2, 2) = -16$   
 23. max =  $f(\pm\sqrt{2}, 1) = 8$ , min =  $f(\pm\sqrt{2}, -1) = -8$   
 25.  $u = \frac{128}{3}, z = 195$  feet    27.  $P(20, 80, 20) = 660$   
 29.  $P\left(\sqrt{\frac{8801}{22}}, 4\sqrt{\frac{8801}{22}}, \sqrt{\frac{8801}{22}}\right) \approx 660.0374989$   
 $660 + \lambda = 660.0375$   
 31.  $x = y$     33.  $f\left(-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}\right) = \sqrt{2}$   
 35.  $\alpha = \beta = \theta = \frac{\pi}{6}; f\left(\frac{\pi}{6}, \frac{\pi}{6}, \frac{\pi}{6}\right) = \frac{1}{8}$   
 39.  $L = 50, K = 10$     41.  $C(L, K) = C(64, 8) = 2400$   
 43.  $f(4, -2, 2) = 24$     45.  $f(1, 1, 2) = 2$   
 47. (a)  $(\pm 1, 0, 0)$  (b)  $(0, \pm 1, \pm 1)$

## Chapter 12 Review Exercises

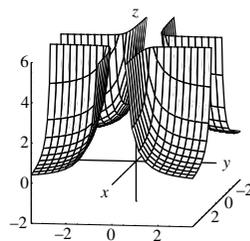
1.



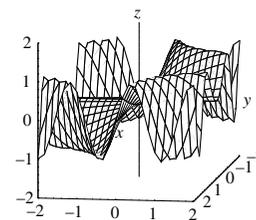
3.



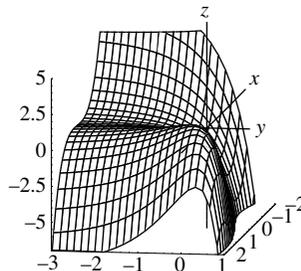
5.



7.



9.



11. (a) D (b) B (c) C (d) A (e) F (f) E  
 13. (a) C (b) A (c) D (d) B    21.  $x \neq 0$   
 23.  $f_x = \frac{4}{y} + (1+xy)e^{xy}, f_y = -\frac{4x}{y^2} + x^2e^{xy}$   
 25.  $f_x = 6xy \cos y - \frac{1}{2\sqrt{x}}, f_y = 3x^2 \cos y - 3x^2y \sin y$   
 29.  $-0.04, 0.06$     31.  $45 - 10(x+2) + 9(y-5)$   
 33.  $(x - \pi) + 2\left(y - \frac{\pi}{2}\right)$   
 35.  $f_{xx} = 24x^2y + 6y^2, f_{yy} = 6x^2, f_{xy} = 8x^3 + 12xy$   
 37.  $3(y+1) - z = 0$   
 39.  $4x + 4(y-2) + 2(z-1) = 0$   
 41.  $8e^{8t} \sin t + (e^{8t} + 2 \sin t) \cos t$   
 43.  $g'(t) = \frac{\partial f}{\partial x}x'(t) + \frac{\partial f}{\partial y}y'(t) + \frac{\partial f}{\partial z}z'(t) + \frac{\partial f}{\partial w}w'(t)$   
 45.  $\frac{\partial z}{\partial x} = -\frac{x+y}{z}, \frac{\partial z}{\partial y} = -\frac{x+y}{z}$     47.  $\langle -\frac{1}{2}, 12\pi - \frac{1}{2} \rangle$   
 49.  $-4$     51.  $-\frac{7}{\sqrt{5}}$     53.  $\pm \frac{1}{\sqrt{145}}\langle 9, -8 \rangle, \pm 4\sqrt{145}$   
 55.  $\pm(1, 0), \pm 4$     57.  $\langle 16, 2 \rangle$   
 59.  $(0, 0)$  relative minimum,  $(2, \pm 8)$  saddles  
 61.  $(\frac{4}{3}, \frac{4}{3})$  relative max,  $(0, 0)$  saddle    63. 212, 112  
 65.  $f(4, 0) = 512, f(0, 0) = 0$   
 67.  $f(1, 2) = 5, f(-1, -2) = -5$   
 69.  $f\left(\sqrt{\frac{1}{2}}, \sqrt{\frac{1}{2}}\right) = f\left(-\sqrt{\frac{1}{2}}, -\sqrt{\frac{1}{2}}\right) = \frac{1}{2}$ ,  
 $f\left(\sqrt{\frac{1}{2}}, -\sqrt{\frac{1}{2}}\right) = f\left(-\sqrt{\frac{1}{2}}, \sqrt{\frac{1}{2}}\right) = -\frac{1}{2}$   
 71.  $(1, 1)$     73. decreases, increases

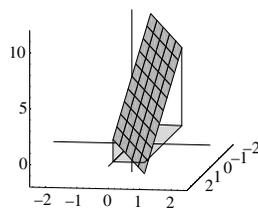
## CHAPTER 13

## Exercises Section 13.1

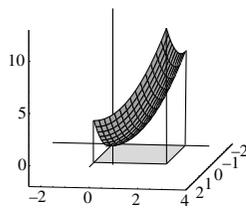
5. 6    7.  $\frac{13}{2}$     9.  $-12$     11. 40    13.  $\frac{16}{3}$

15.  $12(e^2 - 1)$  17.  $\frac{19}{2} - \frac{1}{2}e^6$

19.



21.



23. 2 25.  $\frac{128}{3}$  27.  $\frac{62}{21}$  29.  $e^4 - 1$

31.  $2 \ln 2 \sin 1$  33.  $\frac{1}{2} \neq \frac{2}{3}$

35.  $\int_0^3 \int_1^4 (x^2 + y^2) dy dx = 90$

37.  $\int_{-1}^1 \int_{x^2}^1 (x^2 + y^2) dy dx = \frac{88}{105}$

39.  $\int_{-2}^2 \int_0^{4-y^2} (6 - x - y) dx dy = \frac{704}{15}$

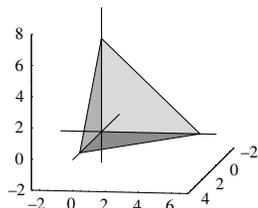
41.  $\int_0^2 \int_0^x y^2 dy dx = \frac{4}{3}$  43. -1.5945 45. 1.6697

47.  $\int_0^2 \int_{y/2}^1 f(x, y) dx dy$  49.  $\int_0^4 \int_0^{x/2} f(x, y) dy dx$

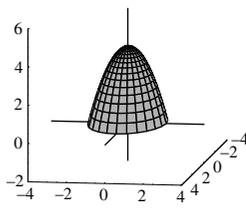
51.  $\int_1^4 \int_0^{\ln y} f(x, y) dx dy$  53.  $\int_0^2 \int_0^y 2e^{y^2} dx dy = e^4 - 1$

55.  $\int_0^1 \int_0^x 3xe^{x^3} dy dx = e - 1$

59.



61.



63. different domains

## Exercises Section 13.2

5.  $\int_{-2}^2 \int_{x^2}^{8-x^2} 1 dy dx = \frac{64}{3}$  7.  $\int_0^2 \int_{y/2}^{3-y} 1 dx dy = 3$

9.  $\int_0^1 \int_{x^2}^{\sqrt{x}} 1 dy dx = \frac{1}{3}$  11. 6 13.  $\frac{40}{3}$

15.  $\frac{1}{2}$  17.  $\frac{5}{12}$  19.  $\frac{8576}{105}$  21.  $\frac{36}{5}$

23.  $\int_0^2 \int_0^{4-x^2} \sqrt{x^2 + y^2} dy dx = 10.275$

25.  $\int_0^4 \int_0^{2-x/2} e^{xy} dy dx = 9.003$

27.  $m = \frac{1}{3}, \bar{x} = \frac{3}{5}, \bar{y} = \frac{12}{35}$

29.  $m = \frac{12}{5}, \bar{x} = \frac{41}{63}, \bar{y} = 0$  31.  $m = 4, \bar{x} = \frac{16}{15}, \bar{y} = \frac{8}{3}$

33. In exercise 30,  $\rho(x, y)$  is not  $x$ -axis symmetric.

35.  $\rho(-x, y) = \rho(x, y)$  37. 1164

39.  $1200(1 - e^{-2/3}) \approx 583.899$

41.  $m = \frac{32}{3}, I_y = \frac{128}{15}, I_x = \frac{512}{7}$

43.  $I_y = \frac{68}{3}, \frac{5}{3}$ ; second spin rate 13.6 times faster

45. 100.531, 508.938

47.  $\frac{12}{5}$  49. same 51. 3.792 53. 50.113

55. (a) total rainfall in region

(b) average rainfall per unit area in region

57.  $\bar{y} = \frac{1}{3}$

## Exercises Section 13.3

5.  $11\pi$  7.  $\pi$  9.  $\frac{\pi}{12}$  11.  $\frac{\pi}{9} + \frac{\sqrt{3}}{6}$  13.  $18\pi$

15.  $\pi - \pi e^{-4}$  17. 0 19.  $\frac{81\pi}{2}$  21.  $\frac{16}{3}$

23.  $\frac{81\pi}{2}$  25.  $\frac{16\pi}{3}$  27.  $\frac{8 - 3\sqrt{3}}{12}\pi$  29. 36

31.  $\pi$  33.  $\int_0^{2\pi} \int_0^2 r^2 dr d\theta = \frac{16\pi}{3}$

35.  $\int_{-\pi/2}^{\pi/2} \int_0^2 r e^{-r^2} dr d\theta = \frac{\pi}{2}(1 - e^{-4})$

37.  $\int_{\pi/4}^{\pi/2} \int_0^{2\sqrt{2}} r^4 dr d\theta = \frac{32\pi\sqrt{2}}{5}$  39.  $1 - e^{-1/16} \approx 0.06$

41.  $\frac{1}{20}(e^{-225/16} - e^{-16}) \approx 0.000000033$  43.  $\frac{31\pi}{320}$

45.  $\bar{x} = 0, \bar{y} = \frac{2}{3}$  47.  $20,000\pi(1 - e^{-1}) \approx 39,717$

49.  $\frac{\pi r^4}{4}$  51.  $V = 2 \int_0^{2\pi} \int_0^a \sqrt{a^2 - r^2} dr d\theta = \frac{4\pi a^3}{3}$

## Exercises Section 13.4

3. 46.831 5. 36.177 7.  $4\sqrt{2}\pi$  9. 583.769

11.  $6\sqrt{11}$  13.  $4\sqrt{6}$  15. 0.931 17. 37.174

19. 25.133 21.  $\sqrt{2}A$  23.  $\frac{A}{|\cos \theta|}$  25.  $4L$

## Exercises Section 13.5

5. 16 7.  $-\frac{2}{3}$  9.  $\frac{4}{15}$  11.  $\frac{171}{5}$  13. 0

15.  $\frac{128\pi}{3}$  17. 64 19. symmetry, yes

21.  $\int_0^2 \int_{-1}^1 \int_{x^2}^1 dz dx dy = \frac{8}{3}$

23.  $\int_{-1}^1 \int_0^{1-y^2} \int_{2-z/2}^4 dx dz dy = \frac{44}{15}$

25.  $\int_{-2}^2 \int_{-\sqrt{4-y^2}}^{\sqrt{4-y^2}} \int_{y^2+z^2}^4 dx dz dy = 8\pi$

27.  $\int_{-3}^3 \int_{-\sqrt{9-x^2}}^{\sqrt{9-x^2}} \int_{\sqrt{x^2+z^2}}^3 dy dz dx = 9\pi$

**1246 Appendix B** Answers to Odd-Numbered Exercises

29. 
$$\int_{-\sqrt{10}}^{\sqrt{10}} \int_{-6}^{4-x^2} \int_0^{y+6} dz dy dx = \frac{160\sqrt{3}}{10}$$

31. 
$$\int_{-1}^1 \int_{x^2}^1 \int_0^{3-x} dy dz dx = 4$$

33.  $m = 32\pi, \bar{x} = \bar{y} = 0, \bar{z} = \frac{8}{3}$

35.  $m = 138, \bar{x} = \frac{186}{115}, \bar{y} = \frac{56}{115}, \bar{z} = \frac{168}{115}$

37. right side is heavier in #34

39. 
$$\begin{aligned} & \int_0^1 \int_0^{2-2y} \int_0^{2-x-2y} 4yz dz dx dy \\ &= \int_0^1 \int_0^{2-2y} \int_0^{2-2y-z} 4yz dx dz dy \\ &= \int_0^2 \int_0^{2-x} \int_0^{1-x/2-z/2} 4yz dy dz dx \end{aligned}$$

41. 
$$\int_0^2 \int_0^{4-2y} \int_0^{4-2y-x} dz dx dy$$

43. 
$$\int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^{\sqrt{1-x^2-z^2}} dy dz dx$$

45. 
$$\int_0^2 \int_{x^2}^4 \int_0^{\sqrt{y-x^2}} dz dy dx$$

**Exercises Section 13.6**

5.  $r = 4$     7.  $r = 4 \cos \theta$     9.  $z = r^2$

11.  $z = \cos(r^2)$     13.  $\theta = \frac{\pi}{4}$

15. 
$$\int_0^{2\pi} \int_0^2 \int_r^{\sqrt{8-r^2}} r f(r \cos \theta, r \sin \theta, z) dz dr d\theta$$

17. 
$$\int_0^{2\pi} \int_0^3 \int_0^{9-r^2} r f(r \cos \theta, r \sin \theta, z) dz dr d\theta$$

19. 
$$\int_0^{2\pi} \int_0^2 \int_{r^2}^4 r f(r \cos \theta, r \sin \theta, z) dz dr d\theta$$

21. 
$$\int_0^{2\pi} \int_0^2 \int_0^{4-r^2} r f(r \cos \theta, y, r \sin \theta) dy dr d\theta$$

23. 
$$\int_0^{2\pi} \int_0^1 \int_{r^2}^{2-r^2} r f(x, r \cos \theta, r \sin \theta) dx dr d\theta$$

25. 
$$\int_0^{2\pi} \int_0^2 \int_1^2 r e^{r^2} dz dr d\theta = \pi(e^4 - 1)$$

27. 
$$\int_0^2 \int_0^{3-3z/2} \int_0^{6-2y-3z} (x+z) dx dy dz = 12$$

29. 
$$\int_0^{2\pi} \int_0^{\sqrt{2}} \int_r^{\sqrt{4-r^2}} z r dz dr d\theta = 2\pi$$

31. 
$$\int_0^2 \int_0^{4-2y} \int_0^{4-x-2y} (x+y) dz dx dy = 8$$

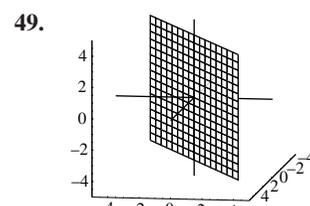
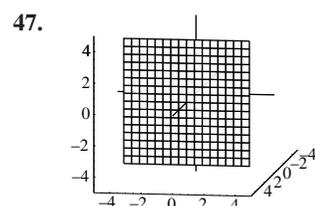
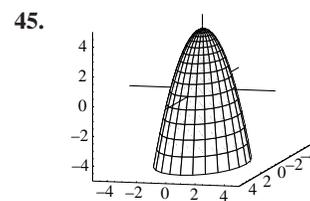
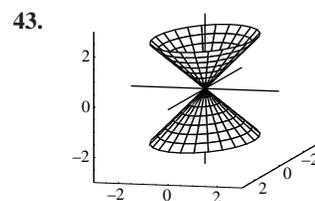
33. 
$$\int_0^{2\pi} \int_0^3 \int_0^{r^2} r e^z dz dr d\theta = \pi(e^9 - 10)$$

35. 
$$\int_0^\pi \int_0^{2 \sin \theta} \int_0^r 2r^2 \cos \theta dz dr d\theta = 0$$

37. 
$$\int_0^{2\pi} \int_0^1 \int_0^r 3z^2 r dz dr d\theta = \frac{2\pi}{5}$$

39. 
$$\int_0^\pi \int_0^2 \int_r^{\sqrt{8-r^2}} 2r dz dr d\theta = \frac{32\pi}{3}(\sqrt{2} - 1)$$

41. 
$$\int_0^{2\pi} \int_0^3 \int_0^{r^2} r^3 dy dr d\theta = 243\pi$$



51.  $m = \frac{128\pi}{3}, \bar{x} = \bar{y} = 0, \bar{z} = \frac{16}{5}$

53.  $m = 10\pi, \bar{x} = 0, \bar{y} = \frac{4}{5}, \bar{z} = \frac{38}{15}$

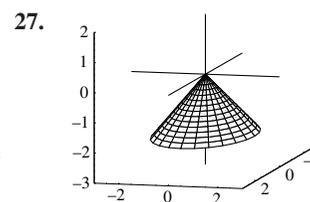
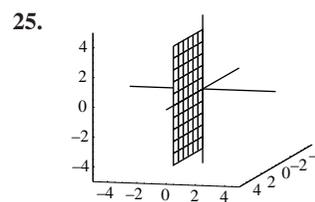
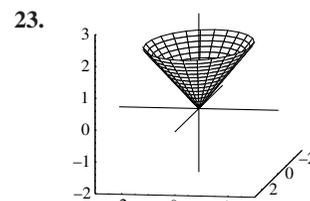
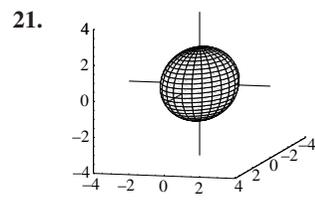
**Exercises Section 13.7**

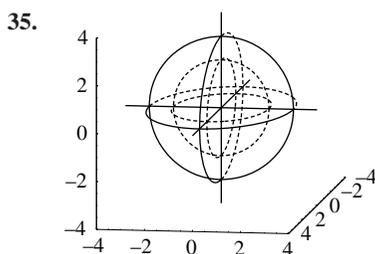
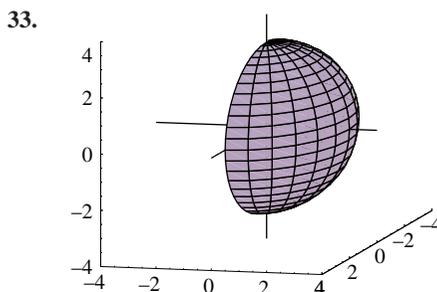
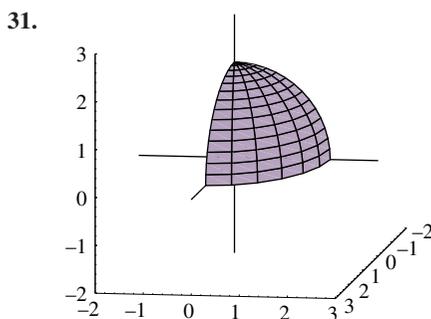
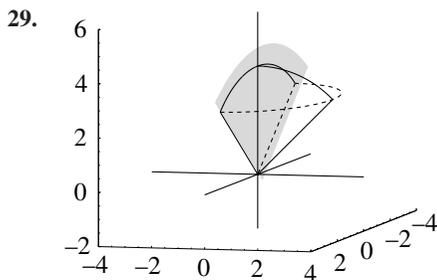
5.  $(0, 0, 4)$     7.  $(4, 0, 0)$     9.  $(\sqrt{2}, 0, \sqrt{2})$

11.  $\left(\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}, 1\right)$     13.  $\rho = 3$

15.  $\theta = \frac{\pi}{4}$  or  $\frac{5\pi}{4}$

17.  $\rho \cos \phi = 2$     19.  $\phi = \frac{\pi}{6}$





37. 
$$\int_0^{2\pi} \int_0^{\pi/2} \int_0^2 e^{\rho^3} \rho^2 \sin \phi \, d\rho \, d\phi \, d\theta = \frac{2}{3}\pi(e^8 - 1)$$

39. 
$$\int_0^{2\pi} \int_0^{\pi/2} \int_0^{\sqrt{2}} \rho^7 \sin \phi \, d\rho \, d\phi \, d\theta = 4\pi$$

41. 
$$\int_0^1 \int_1^2 \int_3^4 (x^2 + y^2 + z^2) \, dz \, dy \, dx = 15$$

43. 
$$\int_0^{2\pi} \int_0^2 \int_0^{4-r^2} r^3 \, dz \, dr \, d\theta = \frac{32\pi}{3}$$

45. 
$$\int_0^{2\pi} \int_0^{\pi/4} \int_0^{\sqrt{2}} \rho^3 \sin \phi \, d\rho \, d\phi \, d\theta = (2 - \sqrt{2})\pi$$

47. 
$$\int_0^{2\pi} \int_0^{\pi/4} \int_0^{4 \cos \phi} \rho^2 \sin \phi \, d\rho \, d\phi \, d\theta = 8\pi$$

49. 
$$\int_0^{2\pi} \int_0^4 \int_r^4 r \, dz \, dr \, d\theta = \frac{64\pi}{3}$$

51. 
$$\int_{-1}^1 \int_{-1}^1 \int_0^{\sqrt{x^2+y^2}} dz \, dy \, dx = 3.061$$

53. 
$$\int_0^{\pi/2} \int_0^{\pi/4} \int_0^2 \rho^2 \sin \phi \, d\rho \, d\phi \, d\theta = \frac{4 - 2\sqrt{2}}{3}\pi$$

55. 
$$\int_0^{2\pi} \int_0^2 \int_0^r r \, dz \, dr \, d\theta = \frac{16\pi}{3}$$

57. 
$$\int_{-\pi/2}^{\pi/2} \int_0^{\pi} \int_0^1 \rho^3 \sin \phi \, d\rho \, d\phi \, d\theta = \frac{\pi}{2}$$

59. 
$$\int_0^{\pi} \int_0^{\pi/4} \int_0^{\sqrt{2}} \rho^5 \sin \phi \, d\rho \, d\phi \, d\theta = \frac{256 - 128\sqrt{2}}{3}\pi$$

61. 
$$\bar{x} = \bar{y} = 0, \bar{z} = \frac{3}{4} + \frac{3\sqrt{2}}{8}$$

### Exercises Section 13.8

3.  $x = \frac{1}{6}(v - u), y = \frac{1}{3}(u + 2v), 2 \leq u \leq 5, 1 \leq v \leq 3$

5.  $x = \frac{1}{4}(u - v), y = \frac{1}{4}(u + 3v), 1 \leq u \leq 3, -3 \leq v \leq -1$

7.  $x = r \cos \theta, y = r \sin \theta, 1 \leq r \leq 2, 0 \leq \theta \leq \frac{\pi}{2}$

9.  $x = r \cos \theta, y = r \sin \theta, 2 \leq r \leq 3, \frac{\pi}{4} \leq \theta \leq \frac{3\pi}{4}$

11.  $x = \sqrt{\frac{1}{2}(v - u)}, y = \frac{1}{2}(u + v), 0 \leq u \leq 2, 2 \leq v \leq 4$

13.  $x = \ln\left(\frac{1}{2}(v - u)\right), y = \frac{1}{2}(u + v), 0 \leq u \leq 1, 3 \leq v \leq 5$

15.  $\frac{7}{2}$     17.  $\frac{13}{3}$     19.  $\frac{7}{3}$     21.  $\frac{1}{6}(e^5 - e^2) \ln 3$

23.  $\frac{9}{4}$     25.  $-2u$     27.  $2$

29.  $x = u - w, y = \frac{1}{2}(-u + v + w), z = \frac{1}{2}(u - v + w),$   
 $1 \leq u \leq 2, 0 \leq v \leq 1, 2 \leq w \leq 4$     31.  $1$

### Chapter 13 Review Exercises

1. 18    3. 207    5.  $(e^{-1} - e^{-4})\pi$     7.  $\frac{2}{3}$     9. 0

11.  $-19.92$     13.  $\frac{4}{3}$     15.  $16\pi$     17.  $\frac{128}{3}$

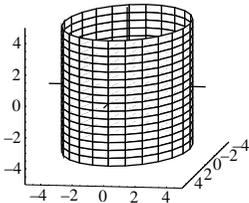
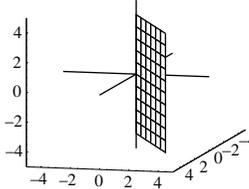
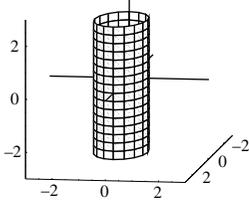
19.  $\frac{64\pi}{3}$     21.  $\frac{1}{3}(16 - 8\sqrt{2})\pi$     23.  $\frac{11\pi}{2}$

25. 
$$\int_0^4 \int_{\sqrt{y}}^2 f(x, y) \, dx \, dy$$

27. 
$$\int_{-\pi/2}^{\pi/2} \int_0^2 2r^2 \cos \theta \, dr \, d\theta = \frac{32}{3}$$

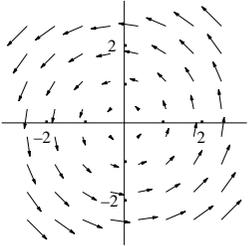
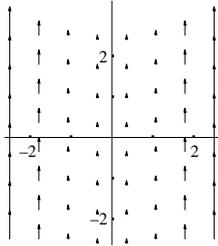
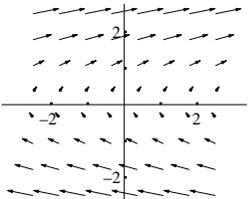
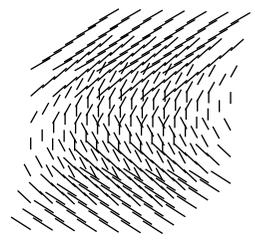
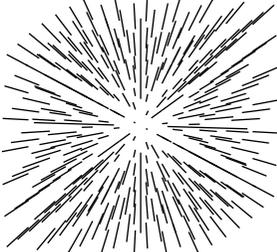
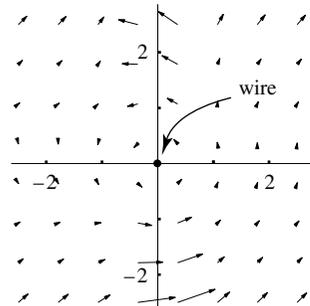
29.  $m = \frac{16}{3}, \bar{x} = \frac{3}{2}, \bar{y} = \frac{9}{4}$

## 1248 Appendix B Answers to Odd-Numbered Exercises

31.  $m = \frac{64}{15}$ ,  $\bar{x} = 0$ ,  $\bar{y} = \frac{23}{28}$ ,  $\bar{z} = \frac{5}{14}$
33.  $\int_0^1 \int_{\sqrt{y}}^{2-y} dx dy = \frac{5}{6}$
35.  $\frac{1}{2}$     37.  $2\sqrt{21}$     39.  $\frac{13\pi}{3}$     41.  $16\pi\sqrt{2}$
43.  $\int_0^2 \int_{-1}^1 \int_{-1}^1 z(x+y) dz dy dx = 0$
45.  $\int_0^{2\pi} \int_0^{\pi/4} \int_0^2 \rho^3 \sin \phi d\rho d\phi d\theta = (8 - 4\sqrt{2})\pi$
47.  $\int_0^2 \int_x^2 \int_0^{6-x-y} f(x, y, z) dz dy dx$
49.  $\int_0^{2\pi} \int_0^{\pi/2} \int_0^2 f(\rho \sin \phi \cos \theta, \rho \sin \phi \sin \theta, \rho \cos \phi) \cdot \rho^2 \sin \phi d\rho d\phi d\theta$
51.  $\int_{\pi/4}^{\pi/2} \int_0^{\sqrt{2}} \int_0^r e^z r dz dr d\theta = \frac{e^{\sqrt{2}}(\sqrt{2}-1)\pi}{4}$
53.  $\int_0^\pi \int_0^{\pi/4} \int_0^{\sqrt{2}} \rho^3 \sin \phi d\rho d\phi d\theta = \left(1 - \frac{\sqrt{2}}{2}\right)\pi$
55. (a)  $r \sin \theta = 3$     (b)  $\rho \sin \phi \sin \theta = 3$
57. (a)  $r^2 + z^2 = 4$     (b)  $\rho = 2$
59. (a)  $z = r$     (b)  $\phi = \frac{\pi}{4}$
61. 
63. 
65. 
67.  $x = \frac{1}{4}(v-u)$ ,  $y = \frac{1}{2}(u+v)$ ,  $-1 \leq u \leq 1$ ,  $2 \leq v \leq 4$
69.  $\frac{1}{2}(e - e^{-1})$     71.  $4uv^2 - 4u^2$

## CHAPTER 14

## Exercises Section 14.1

5. 
7. 
9. 
11. 
13. 
15.  $F_1 = D$ ,  $F_2 = B$ ,  $F_3 = A$ ,  $F_4 = C$     17.  $\langle 2x, 2y \rangle$
19.  $\frac{\langle x, y \rangle}{\sqrt{x^2 + y^2}}$     21.  $\langle e^{-y}, -xe^{-y} \rangle$     23.  $\frac{\langle x, y, z \rangle}{\sqrt{x^2 + y^2 + z^2}}$
25.  $\langle 2xy, x^2 + z, y \rangle$     27.  $f(x, y) = xy + c$     29. not
31.  $f(x, y) = \frac{1}{2}x^2 - x^2y + \frac{1}{3}y^3 + c$
33.  $f(x, y) = -\cos xy + c$
35.  $f(x, y, z) = 2x^2 - xz + \frac{3}{2}y^2 + yz + c$     37. not
39.  $y = \frac{1}{2} \sin x + c$     41.  $y^2 = x^3 + c$
43.  $(y+1)e^{-y} = -\frac{1}{2}x^2 + c$     45.  $y^2 + 1 = ce^{2x}$
47.  $f(x, y, z) = \int_0^x f(u) du + \int_0^y g(u) du + \int_0^z h(u) du + c$
51.  $3r$     55. 

## Exercises Section 14.2

5.  $4\sqrt{13}$     7.  $\frac{21}{2}\sqrt{17}$     9. 4    11. 12    13. -4  
 15.  $3\pi$     17. 25.41    19. -4    21. 14    23.  $\frac{9}{2}$   
 25.  $6\sqrt{6}$     27. -4    29. 31    31. 0    33.  $\frac{518}{3}$   
 35. 26    37. 0    39.  $4\pi - \frac{19}{3}$     41. positive  
 43. zero    45. negative    47. 18.67  
 49.  $\bar{x} = 2.227, \bar{y} = 5.324$   
 51. 99.41    53. 359.9    55.  $\frac{\pi^3}{3}\sqrt{5}$     59.  $4\pi$   
 61.  $\frac{32}{3}$     63. 12    65. (a) 22.1 (b) 15.35 (c) 3.65

## Exercises Section 14.3

5.  $f(x, y) = x^2y - x + c$     7.  $f(x, y) = \frac{x}{y} - x^2 + \frac{1}{2}y^2 + c$   
 9. not    11.  $f(x, y) = e^{xy} + \sin y + c$   
 13.  $f(x, y, z) = xz^2 + x^2y + y - 3z + c$   
 15.  $f(x, y, z) = xyz^2 + \frac{1}{2}x^2 + \frac{1}{2}y^2 + c$   
 17.  $f(x, y) = x^2y - y; 8$     19.  $f(x, y) = e^{xy} - y^2; -16$   
 21.  $f(x, y, z) = xz^2 + x^2y; -38$     23.  $\frac{152}{3}$     25. 18  
 27.  $\sqrt{30} - \sqrt{14}$     29. -2    31.  $10 - e^{18}$   
 33.  $(x-5)^2 + (y-6)^2 = 16$     35. yes    37. no    39. no  
 45. false    47. true    49.  $\tan^{-1}\left(\frac{y}{x}\right) + c, x \neq 0; 0$   
 51. (a) Simply connected (b) Not simply connected

## Exercises Section 14.4

5.  $\pi$     7. 16    9. -54    11.  $\frac{32}{3}$     13.  $6\pi$   
 15.  $\frac{1}{3}$     17.  $\frac{4}{3} + \frac{1}{2}e^2 + \frac{3}{2}e^{-2}$     19.  $\frac{32}{5}$     21. 4  
 23. 0    25.  $8\pi$     27.  $\frac{3}{8}\pi$     29.  $\frac{32}{3}$   
 33.  $\bar{x} = 0, \bar{y} = \frac{4}{7}$     37. 0    39. 0  
 41.  $\{(x, y) \in \mathbb{R}^2 | (x, y) \neq (0, 0)\}; \text{No}$

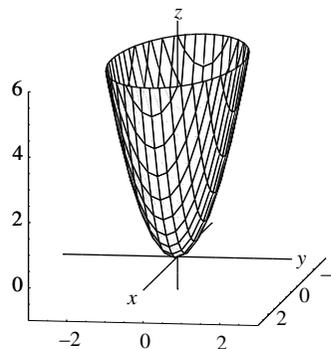
## Exercises Section 14.5

5.  $\langle 0, 0, -3y \rangle, -x$     7.  $\langle -3, 2x, 0 \rangle, 2z$   
 9.  $\langle -y, -2x, -x \rangle, y + z$     11.  $\langle xe^y + 1, -e^y, 0 \rangle, 2x + 1$   
 13.  $\langle -x \sin y, 3y - \cos y, 2x - 3z \rangle, 0$   
 15.  $\langle 2yz - 2z, 2x, 0 \rangle, 2z + 1 + y^2$     17. conservative  
 19. incompressible    21. conservative  
 23. neither    25. incompressible  
 27. conservative    29. conservative  
 31. (a) scalar (b) undefined (c) undefined  
 (d) vector (e) vector  
 35. positive    37. zero    39. negative  
 51.  $-\frac{x^2}{(x^2 + y^2 + z^2)^{3/2}} - \frac{y^2}{(x^2 + y^2 + z^2)^{3/2}}$   
 $-\frac{z^2}{(x^2 + y^2 + z^2)^{3/2}} + \frac{3}{\sqrt{x^2 + y^2 + z^2}}$   
 53. (a) Equal (b) Greater  
 55.  $\mathbf{F} = x\mathbf{i} + y^3\mathbf{j} + z\mathbf{k}, \nabla \cdot \mathbf{F} = 3y^2 + 2$

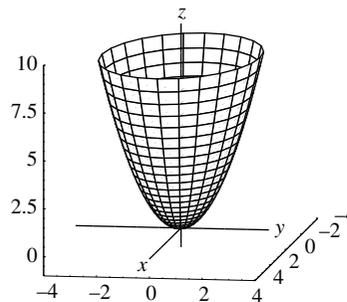
## Exercises Section 14.6

5.  $x = x, y = y, z = 3x + 4y$   
 7.  $x = \cos u \cosh v, y = \sin u \cosh v, z = \sinh v,$   
 $0 \leq u \leq 2\pi, -\infty < v < \infty$   
 9.  $x = 2 \cos \theta, y = 2 \sin \theta, z = z, 0 \leq \theta \leq 2\pi, 0 \leq z \leq 2$   
 11.  $x = r \cos \theta, y = r \sin \theta, z = 4 - r^2,$   
 $0 \leq \theta \leq 2\pi, 0 \leq r \leq 2$

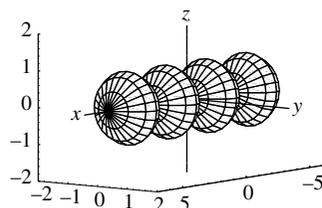
13.



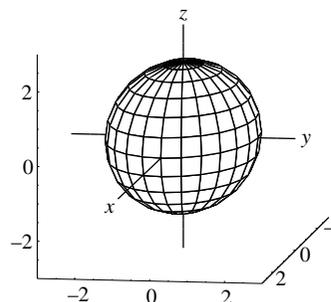
15.



17.



19.



**1250 Appendix B** Answers to Odd-Numbered Exercises

21. (a) A (b) C (c) B    23.  $16\pi\sqrt{2}$   
 25.  $4\pi\sqrt{14}$     27.  $\frac{1}{2}\sqrt{2}$     29.  $4\pi$   
 31.  $\int_1^3 \int_1^2 x\sqrt{14} \, dx \, dy = 3\sqrt{14}$   
 33.  $\int_0^{2\pi} \int_0^2 r^2 \sin\theta\sqrt{4r^2+1} \, dr \, d\theta = 0$   
 35.  $\int_0^{2\pi} \int_0^2 r^3\sqrt{4r^2+1} \, dr \, d\theta = \frac{391\sqrt{17}+1}{60}\pi$   
 37.  $\int_0^{2\pi} \int_0^4 \sqrt{2}r^2 \, dr \, d\theta = \frac{128\sqrt{2}}{3}\pi$   
 39.  $\int_0^{2\pi} \int_0^{\pi/2} 4(4\sin\phi) \, d\phi \, d\theta = 32\pi$   
 41.  $24\pi$     43.  $-18\pi$     45.  $\frac{5}{2}$     47.  $\frac{\pi}{2}$     49.  $\frac{7}{4}$   
 51. 0    53.  $m = 8\sqrt{14}\pi$ ,  $\bar{x} = \bar{y} = 0$ ,  $\bar{z} = 6$   
 55.  $m = 2\pi$ ,  $\bar{x} = \frac{1}{3}$ ,  $\bar{y} = 0$ ,  $\bar{z} = \frac{1}{2}$   
 57.  $\iint_S g(x, y, z) \, dS$   
 $= \iint_R g(f(y, z), y, z) \sqrt{(f_y)^2 + (f_z)^2 + 1} \, dA$   
 where  $S$  is given by  $x = f(y, z)$  for  $(y, z)$  in region  $R: \mathbb{R}^2$ .  
 59.  $\frac{3\pi}{2}$     61.  $198.8\pi$   
 63.  $0.474\pi$     65.  $23.66$   
 67. Flow lines don't cross boundary.

**Exercises Section 14.7**

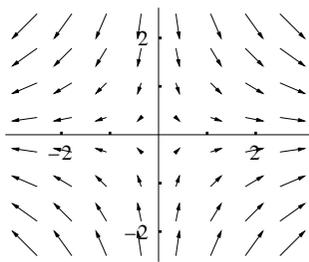
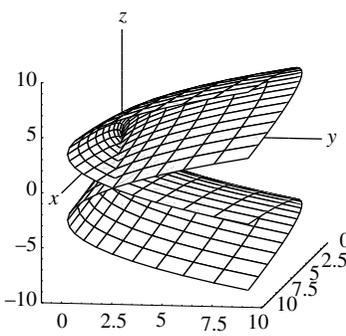
5.  $\frac{3}{2}$     7.  $\pi$     9. 0    11. 8    13.  $32\pi$   
 15.  $\frac{64\pi}{3}$     17.  $4\pi$     19.  $\frac{6\pi}{5}$     21. 0    23.  $\frac{\pi}{2}$   
 25.  $\pi$     27.  $224\pi$     29.  $\frac{27}{5}$     31.  $\frac{512}{3}$

**Exercises Section 14.8**

5. 0    7.  $4\pi$     9.  $-\frac{4}{3}$     11.  $-\pi$     13. 0  
 15. 1    17. 0    19.  $-4\pi$     21.  $4\pi$     23. 0  
 25. 0

33. Both surfaces  $S_1$  and  $S_2$  should be positively oriented, or both negatively oriented.

**Chapter 14 Review Exercises**

1. 
3.  $F_1 = D$ ,  $F_2 = C$ ,  $F_3 = B$ ,  $F_4 = A$   
 5.  $f(x, y) = xy - x^2y^2 + y + c$     7. not  
 9.  $y^3 = 3x^2 + c$     13. 18    15.  $18\pi$     17. 0  
 19. 0    21.  $3\pi - 4$     23. zero    25.  $40\pi$   
 27. 66    29. 3    31. 10    33. conservative    35.  $\frac{1}{3}$   
 37. -2    39.  $\frac{32}{3}$     41.  $6\pi$   
 43.  $(0, 0, 0)$ ,  $3x^2 - 3y^2$     45.  $(0, 0, 0)$ ,  $2 + 2z^2 + 2y^2$   
 47. neither    49. both    51. positive  
 53. 
55. (a) B (b) C (c) A    57.  $\frac{1}{8}(17^{3/2} - 5^{3/2})\pi$   
 59.  $-8\sqrt{14}$     61.  $4\pi\sqrt{26}$     63. 0  
 65.  $m = \frac{1}{3}(17\sqrt{17} - 1)\pi$ ,  $\bar{x} = \bar{y} = 0$ ,  $\bar{z} = \frac{1 + 391\sqrt{17}}{10(17\sqrt{17} - 1)}$   
 67.  $\frac{16}{3}$     69.  $\frac{304}{5}$     71.  $\frac{8\pi}{3}$     73. 0    75. 0  
 77. 0