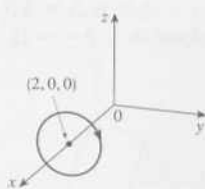


**Exercícios**

1. (a)



(b)  $\cos t \mathbf{j} - \sin t \mathbf{k}, -\sin t \mathbf{j} - \cos t \mathbf{k}$

3.  $\mathbf{r}(t) = 4 \cos t \mathbf{i} + 4 \sin t \mathbf{j} + (5 - 4 \cos t) \mathbf{k}, 0 \leq t \leq 2\pi$

5.  $\frac{5}{6} \mathbf{i} + \frac{9}{4} \mathbf{j} + \frac{1}{3} \mathbf{k}$     7. 15,9241    9.  $\pi/2$

11. (a)  $\langle t^2, t, 1 \rangle / \sqrt{t^4 + t^2 + 1}$

(b)  $\langle 2t, 1 - t^4, -2t^3 - t \rangle / \sqrt{t^8 + 4t^6 + 2t^4 + 5t^2}$

(c)  $\sqrt{t^8 + 4t^6 + 2t^4 + 5t^2} / (t^4 + t^2 + 1)^2$

13.  $12/17^{3/2}$     15.  $x - 2y + 2\pi = 0$

17.  $\mathbf{v}(t) = 2\sqrt{2} \mathbf{i} + 2e^{2t} \mathbf{j} - 2e^{-2t} \mathbf{k}, |\mathbf{v}(t)| = 2(e^{2t} + e^{-2t}),$

$\mathbf{a}(t) = 4e^{2t} \mathbf{j} + 4e^{-2t} \mathbf{k}$

19. (a) Em torno de 3,8 pés acima do solo, 60,8 pés a partir do atleta

 (b)  $\approx 21,4$  pés    (c)  $\approx 64,2$  pés do atleta

21. (c)  $-2e^{-t} \mathbf{v}_d + e^{-t} \mathbf{R}$

**Problemas Quentes** □

1. (a)  $\mathbf{v} = \omega R(-\sin \omega t \mathbf{i} + \cos \omega t \mathbf{j})$     (c)  $\mathbf{a} = -\omega^2 \mathbf{r}$

3. (a)  $90^\circ, v_0^2/(2g)$

5. (b)  $\mathbf{R}(t) = (m/k)(1 - e^{-kt/m}) \mathbf{v}_0 + (gm/k)[(m/k)(1 - e^{-kt/m}) - t] \mathbf{j}$

 7. (a)  $\approx 0,94$  pés à direita do eixo da mesa,  $\approx 15$  pés/s

 (b)  $\approx 7,6^\circ$     (c)  $\approx 2,13$  pés à direita da aresta da mesa.

**Capítulo 14**
**Exercícios 14.1** □

 1. (a)  $-7$ ; uma temperatura de  $8^\circ\text{C}$  com um vento soprando a  $60$  km/h nos faz sentir o equivalente a  $-7^\circ\text{C}$  sem vento.

 (b) Quando a temperatura é  $-12^\circ\text{C}$ , qual velocidade do vento fornece um vento frio de  $-26^\circ\text{C}$ ?  $20$  km/h

 (c) Com uma velocidade do vento de  $80$  km/h, qual temperatura fornece um vento frio de  $-14^\circ\text{C}$ ?  $4^\circ\text{C}$ 

 (d) Uma função da velocidade do vento que fornece valores de vento frio quando a temperatura é  $-4^\circ\text{C}$ 

 (e) Uma função da temperatura que fornece valores de vento frio quando a velocidade do vento é  $50$  km/h

3. Sim

5. (a) 25; um vento de 40 nós sopra no oceano por 15 horas criando ondas de cerca de 25 pés de altura.

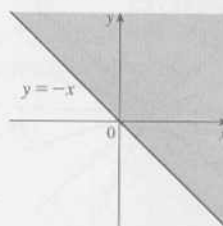
 (b)  $f(30, t)$  é uma função de  $t$ , dando a altura de ondas produzidas por ventos de 30 nós que sopram por  $t$  horas.

 (c)  $f(v, 30)$  é uma função de  $v$ , dando a altura de ondas produzidas por ventos de velocidade  $v$  que sopram por 30 horas.

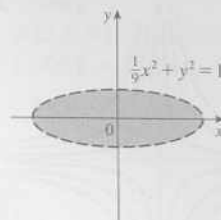
7. (a) 1    (b)  $\mathbb{R}^2$     (c)  $\{z | z > 0\}$

9. (a) 0    (b)  $\{(x, y, z) | x - y + z > 0\}$     (c)  $\mathbb{R}$

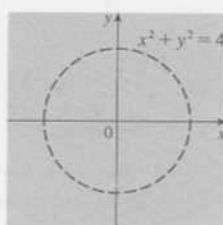
11.  $\{(x, y) | y \geq -x\}$



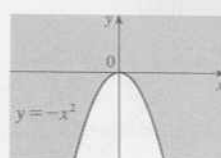
13.  $\{(x, y) | \frac{1}{9}x^2 + y^2 < 1\}$



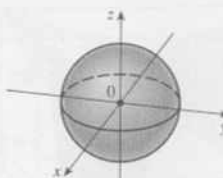
15.  $\{(x, y) | x^2 + y^2 \neq 4\}$



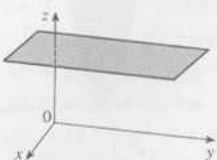
17.  $\{(x, y) | y \geq -x^2\}$



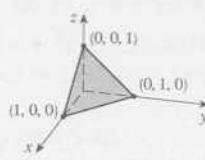
19.  $\{(x, y, z) | x^2 + y^2 + z^2 \leq 1\}$



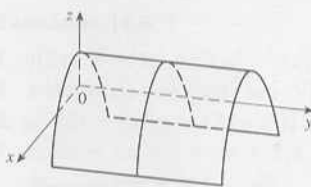
21.  $z = 3$ , Plano horizontal



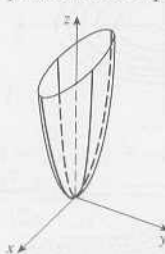
23.  $x + y + z = 1$ , plano



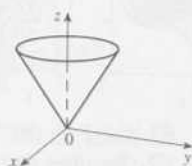
25.  $z = 1 - x^2$



27.  $z = x^2 + 9y^2$ ,  
parabolóide elíptico



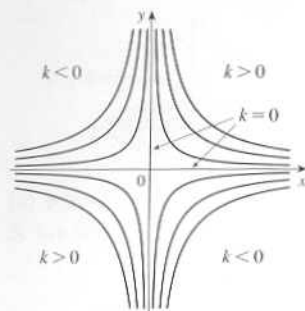
29.  $z = \sqrt{x^2 + y^2}$ ,  
topo da metade do cone



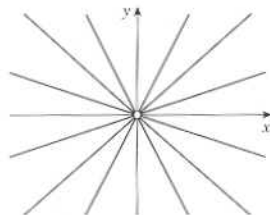
31.  $\approx 56, \approx 35$

33. Íngreme; aproximadamente plana

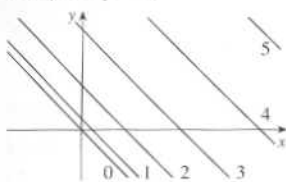
35.  $xy = k$



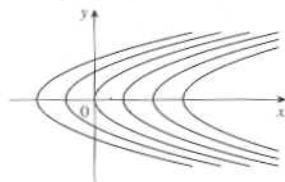
37.  $x/y = k$



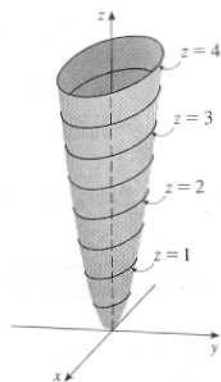
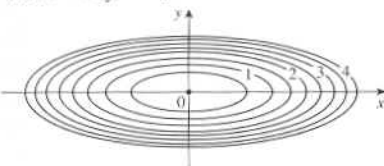
39.  $\sqrt{x+y} = k$



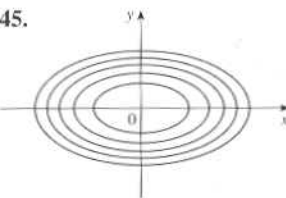
41.  $x = y^2 + k$



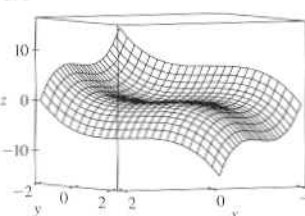
43.  $x^2 + 9y^2 = k$



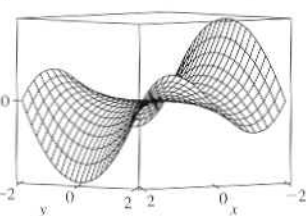
45.



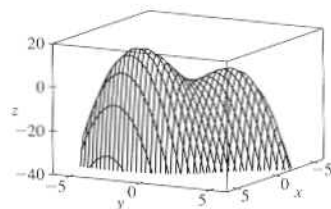
47.



49.

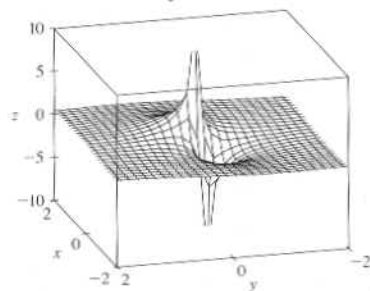


61.



$f$  parece ter um valor mínimo de cerca de 15. Há 2 pontos máximos locais, mas nenhum ponto mínimo local.

63.



Os valores da função tendem a 0 quando  $x$  torna-se grande; quando  $(x, y)$  tende à origem,  $f$  aproxima-se de  $\pm\infty$  ou 0, dependendo da direção de aproximação.

65. Se  $c = 0$ , o gráfico é uma superfície cilíndrica. Para  $c > 0$ , as curvas de nível são elipses. O gráfico das curvas ascende quando deixamos a origem, e o grau de inclinação cresce quando  $c$  cresce. Para  $c < 0$ , as curvas de nível são hipérbolas. O gráfico das curvas ascende na direção  $y$  e descende, aproximam-se do plano  $xy$ , na direção  $x$  dando uma aparência da forma sela próximo de  $(0, 0, 1)$ .

67. (b)  $y = 0,75x + 0,01$

**Exercícios 14.2** □

1. Nenhum; se  $f$  for contínua,  $f(3, 1) = 6$     3.  $-\frac{5}{2}$     5. 2025  
 7. Não existe    9. Não existe    11. 0  
 13. Não existe    15. 2    17. 1    19. Não existe  
 21. O gráfico mostra que a função aproxima-se de números diferentes ao longo de retas diferentes.  
 23.  $h(x, y) = 4x^2 + 9y^2 + 12xy - 24x - 36y + 36 + \sqrt{2x + 3y - 6}$ ;  $\{(x, y) \mid 2x + 3y \geq 6\}$   
 25. Ao longo da reta  $y = x$     27.  $\{(x, y) \mid y \neq x^2\}$   
 29.  $\{(x, y) \mid y \geq 0\}$     31.  $\{(x, y) \mid x \geq |y|\}$   
 33.  $\{(x, y, z) \mid z \neq x^2 + y^2\}$     35.  $\{(x, y) \mid (x, y) \neq (0, 0)\}$   
 37. 0    39. 0

**Exercícios 14.3** □

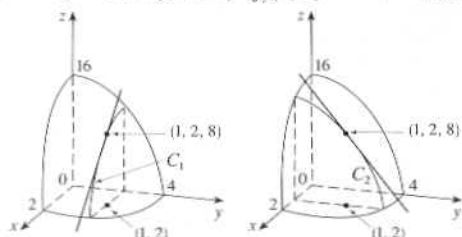
1. (a) A taxa da variação da temperatura quando varia a longitude, com latitude e tempo fixados; a taxa de variação quando varia apenas a latitude; a taxa de mudança quando varia apenas o tempo.  
 (b) Positivo, negativo, positivo  
 3. (a)  $f_T(12, 20) \approx 1,375$ ; para uma temperatura de  $12^\circ\text{C}$  e velocidade do vento de  $20\text{ km/h}$ , o índice do resfriamento da superfície realizado pelo vento aumenta  $1,375^\circ\text{C}$  para cada aumento de grau da temperatura.  
 $f_V(12, 20) \approx -0,3$ ; para uma temperatura de  $12^\circ\text{C}$  e velocidade do vento de  $20\text{ km/h}$ , o índice do resfriamento da superfície realizado pelo vento decresce  $0,3^\circ\text{C}$  para cada aumento em  $\text{km/h}$  da velocidade do vento.

51. (a) B    (b) III    53. (a) F    (b) V  
 55. (a) D    (b) IV    57. Famílias de planos paralelos  
 59. Famílias de hiperbolóides de uma ou duas folhas com eixo o eixo  $y$

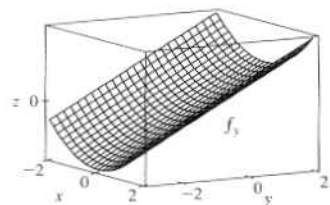
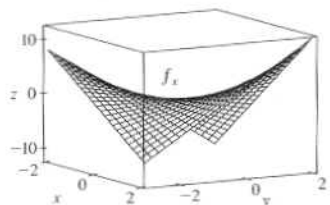
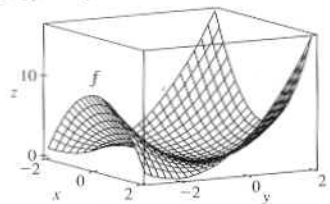
(b) Positivo, negativo (c) 0

5.  $c = f, b = f_x, a = f_y$

7.  $f_x(1, 2) = -8 =$  inclinação de  $C_1$   $f_y(1, 2) = -4 =$  inclinação de  $C_2$



9.  $f_x = 2x + 2xy, f_y = 2y + x^2$



11.  $f_x(x, y) = 3, f_y(x, y) = -8y^3$

13.  $\partial z/\partial x = e^{3y}, \partial z/\partial y = 3xe^{3y}$

15.  $f_x(x, y) = 2y/(x + y)^2, f_y(x, y) = -2x/(x + y)^2$

17.  $\partial w/\partial \alpha = \cos \alpha \cos \beta, \partial w/\partial \beta = -\sin \alpha \sin \beta$

19.  $f_u = v/(u^2 + v^2), f_v = -u/(u^2 + v^2)$

21.  $\partial z/\partial x = 1/\sqrt{x^2 + y^2}, \partial z/\partial y = y/(x^2 + y^2 + x\sqrt{x^2 + y^2})$

23.  $f_x = y^2z^3, f_y = 2xy^2z^3 + 3z, f_z = 3xy^2z^2 + 3y$

25.  $\partial w/\partial x = 1/(x + 2y + 3z), \partial w/\partial y = 2/(x + 2y + 3z),$

$\partial w/\partial z = 3/(x + 2y + 3z)$

27.  $\partial u/\partial x = e^{-t} \sin \theta, \partial u/\partial t = -xe^{-t} \sin \theta, \partial u/\partial \theta = xe^{-t} \cos \theta$

29.  $f_x = 1/(z - t), f_y = 1/(t - z), f_z = (y - x)/(z - t)^2,$

$f_t = (x - y)/(z - t)^2$

31.  $\partial u/\partial x_i = x_i/\sqrt{x_1^2 + x_2^2 + \dots + x_n^2}$  33.  $\frac{3}{5}$  35.  $-\frac{1}{3}$

37.  $f_x(x, y) = 2x - y, f_y(x, y) = 4y - x$

39.  $(y - z)/(x - y), (x + z)/(x - y)$

41.  $(x - y - z)/(x + z), (y - x)/(x + z)$

43. (a)  $f'(x), g'(y)$  (b)  $f'(x + y), f'(x + y)$

45.  $f_{xx} = 12x^2 - 6y^3, f_{yy} = -18xy^2 = f_{yx}, f_{yy} = -18x^2y$

47.  $z_{xx} = -2y/(x + y)^3, z_{xy} = (x - y)/(x + y)^3 = z_{yx},$

$z_{yy} = 2x/(x + y)^3$

49.  $u_{xy} = e^{-t} \sin t, u_{yx} = -e^{-t} \cos t = u_{tx}, u_{tt} = -e^{-t} \sin t$

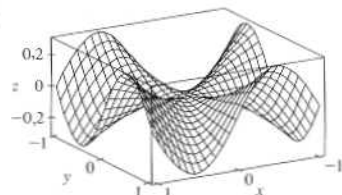
55.  $-48xy$  57.  $48x^3y^3z^2$  59.  $-\sin y$

61.  $72yz^2/(x + 2y^2 + 3z^2)^3$  63.  $\approx 12,2, \approx 16,8, \approx 23,25$

75.  $R^2/R_1^2$  79. Não 81.  $x = 1 + t, y = 2, z = 2 - 2t$

85.  $-2$

87. (a)



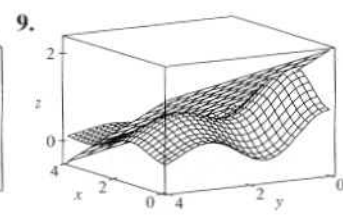
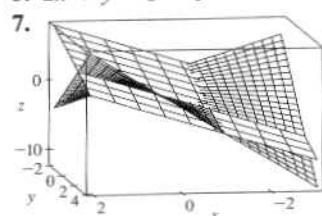
(b)  $f_x(x, y) = \frac{x^4y + 4x^2y^3 - y^5}{(x^2 + y^2)^2}, f_y(x, y) = \frac{x^5 - 4x^3y^2 - xy^4}{(x^2 + y^2)^2}$

(c) 0, 0 (e) Não, uma vez que  $f_{xy}$  e  $f_{yx}$  não são contínuas.

Exercícios 14.4 □

1.  $8x + 10y - z = 9$  3.  $x - 2y + z = 4$

5.  $2x + y - z = 1$



11.  $2x + \frac{1}{4}y - 1$  13.  $x + 1$  15.  $\frac{1}{2}x + y + \frac{1}{4}\pi - \frac{1}{2}$

17.  $-\frac{2}{3}x - \frac{7}{3}y + \frac{20}{3}; 2,846$  19.  $\frac{3}{7}x + \frac{2}{7}y + \frac{6}{7}z; 6,9914$

21.  $4T + H - 329; 129^\circ\text{F}$  23.  $dz = 2xy^3 dx + 3x^2y^2 dy$

25.  $du = e^t \sin \theta dt + e^t \cos \theta d\theta$

27.  $dw = (x^2 + y^2 + z^2)^{-1}(x dx + y dy + z dz)$

29.  $\Delta z = 0,9225, dz = 0,9$  31.  $5,4 \text{ cm}^2$  33.  $16 \text{ cm}^3$

35.  $150$  37.  $\frac{1}{17} \approx 0,059 \Omega$  39.  $\epsilon_1 = \Delta x, \epsilon_2 = \Delta y$

Exercícios 14.5 □

1.  $4(2xy + y^2)t^3 - 3(x^2 + 2xy)t^2$

3.  $\pi \cos x \cos y - (\sin x \sin y)/(2\sqrt{t})$

5.  $e^{y/z}[2t - (x/z) - (2xy/z^2)]$

7.  $\partial z/\partial s = 2x + y + xt + 2yt, \partial z/\partial t = 2x + y + xs + 2ys$

9.  $\frac{\partial z}{\partial s} = \frac{4st + \ln t}{1 + (2x + y)^2}, \frac{\partial z}{\partial t} = \frac{2s^2 + s/t}{1 + (2x + y)^2}$

11.  $\frac{\partial z}{\partial s} = e^t \left( t \cos \theta - \frac{s}{\sqrt{s^2 + t^2}} \sin \theta \right),$

$\frac{\partial z}{\partial t} = e^t \left( s \cos \theta - \frac{t}{\sqrt{s^2 + t^2}} \sin \theta \right)$

13. 62

15.  $\frac{\partial u}{\partial r} = \frac{\partial u}{\partial x} \frac{\partial x}{\partial r} + \frac{\partial u}{\partial y} \frac{\partial y}{\partial r}, \frac{\partial u}{\partial s} = \frac{\partial u}{\partial x} \frac{\partial x}{\partial s} + \frac{\partial u}{\partial y} \frac{\partial y}{\partial s},$

$\frac{\partial u}{\partial t} = \frac{\partial u}{\partial x} \frac{\partial x}{\partial t} + \frac{\partial u}{\partial y} \frac{\partial y}{\partial t}$

$$17. \frac{\partial v}{\partial x} = \frac{\partial v}{\partial p} \frac{\partial p}{\partial x} + \frac{\partial v}{\partial q} \frac{\partial q}{\partial x} + \frac{\partial v}{\partial r} \frac{\partial r}{\partial x}$$

$$\frac{\partial v}{\partial y} = \frac{\partial v}{\partial p} \frac{\partial p}{\partial y} + \frac{\partial v}{\partial q} \frac{\partial q}{\partial y} + \frac{\partial v}{\partial r} \frac{\partial r}{\partial y}$$

$$\frac{\partial v}{\partial z} = \frac{\partial v}{\partial p} \frac{\partial p}{\partial z} + \frac{\partial v}{\partial q} \frac{\partial q}{\partial z} + \frac{\partial v}{\partial r} \frac{\partial r}{\partial z}$$

19. 2, 0    21. 0, 0, 4

23.  $\partial u/\partial p = 2(z-x)/(y+z)^2 = -t/p^2$ ,  $\partial u/\partial r = 0$ ,

$\partial u/\partial t = 2/(y+z) = 1/p$

25.  $(y-2x)/(3y^2-x)$     27.  $\frac{\text{sen}(x-y) + e^y}{\text{sen}(x-y) - xe^y}$

29.  $-\frac{y^2 + 2xz}{2yz + x^2}$ ,  $-\frac{2xy + z^2}{2yz + x^2}$

31.  $-(e^y + ze^x)/(y + e^x)$ ,  $-(xe^y + z)/(y + e^x)$     33. 2 °C/s

35.  $\approx -0,33$  m/s por minuto

37. (a) 6 m<sup>3</sup>/s (b) 10 m<sup>2</sup>/s (c) 0 m/s    39. -0,27 L/s

41. (a)  $\partial z/\partial r = (\partial z/\partial x) \cos \theta + (\partial z/\partial y) \sin \theta$ ,

$\partial z/\partial \theta = -(\partial z/\partial x)r \sin \theta + (\partial z/\partial y)r \cos \theta$

47.  $4rs \partial^2 z/\partial x^2 + (4r^2 + 4s^2) \partial^2 z/\partial x \partial y + 4rs \partial^2 z/\partial y^2 + 2 \partial z/\partial y$

**Exercícios 14.6** □

1.  $\approx -0,1$  milibares/min    3.  $7\sqrt{3} - 16$     5.  $\frac{5}{16}\sqrt{3} + \frac{1}{4}$

7. (a)  $\nabla f(x, y) = \langle 5y^2 - 12x^2y, 10xy - 4x^3 \rangle$

(b)  $\langle -4, 16 \rangle$     (c) 172/13

9. (a)  $\nabla f(x, y, z) = \langle y^2z^3, 2xyz^3, 3xy^2z^2 \rangle$     (b)  $\langle 4, -4, 12 \rangle$

(c)  $20/\sqrt{3}$

11. 23/10    13.  $4\sqrt{2}$     15. 4/9    17.  $-\pi/(4\sqrt{3})$

19. 2/5    21.  $\sqrt{5}, \langle 1, 2 \rangle$     23. 1,  $\langle 0, 1 \rangle$

25.  $\sqrt{11}, \langle 1, -1, -3 \rangle$     27. (b)  $\langle -12, 92 \rangle$

29. (a)  $-40/(3\sqrt{3})$

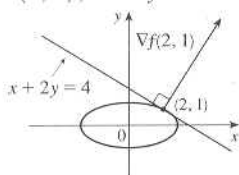
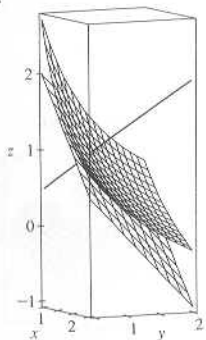
31. (a)  $32/\sqrt{3}$     (b)  $\langle 38, 6, 12 \rangle$     (c)  $2\sqrt{406}$     33.  $\frac{327}{13}$

37. (a)  $4x - 2y + 3z = 21$     (b)  $\frac{x-4}{8} = \frac{y+1}{-4} = \frac{z-1}{6}$

39. (a)  $3x - y + z = 4$     (b)  $(x-1)/3 = -y = z-1$

41. (a)  $x + y - z = 1$     (b)  $x-1 = y = -z$

43.    45.  $\langle 4, 8 \rangle, x + 2y = 4$



51.  $(\pm\sqrt{6}/3, \mp 2\sqrt{6}/3, \pm\sqrt{6}/2)$

57.  $x = -1 - 10t, y = 1 - 16t, z = 2 - 12t$

61. Se  $\mathbf{u} = \langle a, b \rangle$  e  $\mathbf{v} = \langle c, d \rangle$ , então  $af_x + bf_y$  e  $cf_x + df_y$  são desconhecidas; logo, vamos resolver as equações lineares para  $f_x$  e  $f_y$ .

**Exercícios 14.7** □

1. (a)  $f$  tem um mínimo local em (1, 1).

(b)  $f$  tem um ponto de sela em (1, 1).

3. Mínimo local em (1, 1), ponto de sela em (0, 0)

5. Máximo  $f(-1, \frac{1}{2}) = 11$

7. Mínimo  $f(0, 0) = 4$ , pontos de sela  $(\pm\sqrt{2}, -1)$

9.  $f$  tem um valor máximo local de 1 em todos os pontos da forma  $(x_0, x_0)$ .

11. Ponto de sela (1, 2)    13. Máximo  $f(-\frac{1}{2}, 4) = -6$

15. Nenhum    17. Pontos de sela  $(0, n\pi)$ ,  $n$  um inteiro

19. Máximo  $f(0, 0) = 2$ , mínimo  $f(0, 2) = -2$ ,

pontos de sela  $(\pm 1, 1)$

21. Máximo  $f(\pi/3, \pi/3) = 3\sqrt{3}/2$ ,

mínimo  $f(5\pi/3, 5\pi/3) = -3\sqrt{3}/2$

23. Mínimos  $f(-1,714, 0) \approx -9,200$ ,  $f(1,402, 0) \approx 0,242$ ,

ponto de sela  $(0,312, 0)$ , ponto mais baixo  $(-1,714, 0, -9,200)$

25. Máximos  $f(-1,267, 0) \approx 1,310$ ,  $f(1,629, \pm 1,063) \approx 8,105$ ,

pontos de sela  $(-0,259, 0), (1,526, 0)$ ,

pontos de máximo  $(1,629, \pm 1,063, 8,105)$

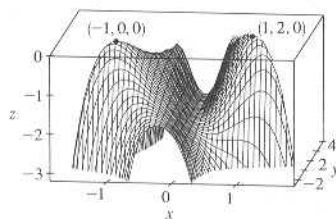
27. Mínimo  $f(4, 0) = -7$ , máximo  $f(4, 5) = 13$

29. Máximo  $f(\pm 1, 1) = 7$ , mínimo  $f(0, 0) = 4$

31. Máximo  $f(2, 4) = 3$ , mínimo  $f(-2, 4) = -9$

33. Máximo  $f(1, 0) = 2$ , mínimo  $f(-1, 0) = -2$

35.



37.  $7/\sqrt{61}$     39.  $(0, 0, 1), (0, 0, -1)$     41.  $\frac{100}{3}, \frac{100}{3}, \frac{100}{3}$

43.  $16/\sqrt{3}$     45.  $\frac{4}{3}$     47. Cubo, aresta de comprimento  $c/12$

49. Base quadrada de lado 40 cm, altura 20 cm

**Exercícios 14.8** □

1.  $\approx 59, 30$     3. Máximos  $f(\pm 1, 0) = 1$ , mínimos  $f(0, \pm 1) = -1$

5. Máximos  $f(\pm 2, 1) = 4$ , mínimos  $f(\pm 2, -1) = -4$

7. Máximo  $f(1, 3, 5) = 70$ , mínimo  $f(-1, -3, -5) = -70$

9. Máximo  $2/\sqrt{3}$ , mínimo  $-2/\sqrt{3}$

11. Máximo  $\sqrt{3}$ , mínimo 1

13. Máximo  $f(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}) = 2$ ,

mínimo  $f(-\frac{1}{2}, -\frac{1}{2}, -\frac{1}{2}) = -2$

15. Máximo  $f(1, \sqrt{2}, -\sqrt{2}) = 1 + 2\sqrt{2}$ ,

mínimo  $f(1, -\sqrt{2}, \sqrt{2}) = 1 - 2\sqrt{2}$

17. Máximo  $\frac{3}{2}$ , mínimo  $\frac{1}{2}$

19. Máximos  $f(\pm 1/\sqrt{2}, \mp 1/(2\sqrt{2})) = e^{1/4}$ ,

mínimos  $f(\pm 1/\sqrt{2}, \pm 1/(2\sqrt{2})) = e^{-1/4}$

25-37. Veja os Exercícios 37-49 na Seção 14.7.

39. Mais próximo  $(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$ , mais afastado  $(-1, -1, 2)$

41. (a)  $c/n$     (b) Quando  $x_1 = x_2 = \dots = x_n$

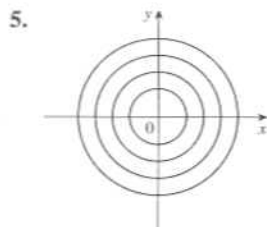
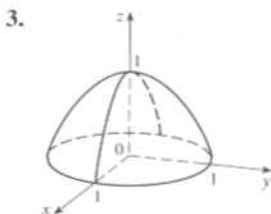
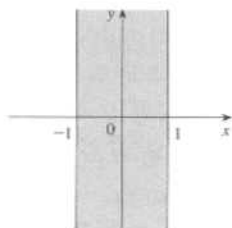
Capítulo 14 Revisão □

Testes Falso-verdadeiro

1. Verdadeiro 3. Falso 5. Falso 7. Verdadeiro  
9. Falso 11. Verdadeiro

Exercícios

1.  $\{(x, y) \mid -1 \leq x \leq 1\}$



7.  $\frac{2}{3}$   
9. (a)  $\approx 3,5 \text{ }^\circ\text{C/m}$ ,  $-3,0 \text{ }^\circ\text{C/m}$   
(b)  $\approx 0,35 \text{ }^\circ\text{C/m}$  pela Equação 14.6.9 (A Definição 14.6.2 fornece  $\approx 1,1 \text{ }^\circ\text{C/m}$ .)  
(c)  $-0,25$

11.  $f_x = 12x^3 - \sqrt{y}$ ,  $f_y = -\frac{1}{2}x/\sqrt{y}$   
13.  $f_x = 2e^{2x} \cos \pi t$ ,  $f_t = -\pi e^{2x} \sin \pi t$   
15.  $f_x = y^2$ ,  $f_y = xzy^{z-1}$ ,  $f_z = xy^2 \ln y$   
17.  $f_{xx} = 2y^3 - 24x^2$ ,  $f_{xy} = 6xy^2$ ,  $f_{yy} = 6x^2y + 2$   
19.  $f_{xx} = 0$ ,  $f_{yy} = 2xz^3$ ,  $f_{zz} = 6xy^2z$ ,  $f_{xy} = 2yz^3$ ,  $f_{xz} = 3y^2z^2$ ,  $f_{yz} = 6xyz^2$   
23.  $6y - z = 1$  25.  $x + 3y + 9z = 18$   
27.  $3x + 4y + 3z = 14$  29.  $(\pm\sqrt{2/7}, \pm 1/\sqrt{14}, \mp 3/\sqrt{14})$   
31.  $60x + \frac{24}{5}y + \frac{32}{5}z - 120$ ; 38,656  
33.  $e^t + 2(y/z)(3t^2 + 4) - 2t(y^2/z^2)$  35.  $-47, 108$   
41.  $ze^{x\sqrt{y}} \langle z\sqrt{y}, xz/(2\sqrt{y}), 2 \rangle$  43.  $\frac{43}{5}$  45.  $\sqrt{145}/2, \langle 4, \frac{9}{2} \rangle$   
47.  $\approx \frac{5}{8}$  nós/mi 49. Mínimos  $f(-4, 1) = -9$   
51. Máximo  $f(1, 1) = 1$ ; pontos de sela  $(0, 0)$ ,  $(0, 3)$ ,  $(3, 0)$   
53. Máximo  $f(1, 2) = 4$ , mínimo  $f(2, 4) = -64$   
55. Máximo  $f(-1, 0) = 2$ , mínimos  $f(1, \pm 1) = -3$ , pontos de sela  $(-1, \pm 1)$ ,  $(1, 0)$   
57. Máximo  $f(\pm\sqrt{2/3}, 1/\sqrt{3}) = 2/(3\sqrt{3})$ , mínimo  $f(\pm\sqrt{2/3}, -1/\sqrt{3}) = -2/(3\sqrt{3})$   
59. Máximo  $f(3, 3, 3) = 9$ , mínimo  $f(1, 1, -1) = f(1, -1, 1) = f(-1, 1, 1) = 1$   
61.  $(\pm 3^{-1/4}, 3^{-1/4}\sqrt{2}, \pm 3^{1/4})$ ,  $(\pm 3^{-1/4}, -3^{-1/4}\sqrt{2}, \pm 3^{1/4})$   
63.  $P(2 - \sqrt{3})$ ,  $P(3 - \sqrt{3})/6$ ,  $P(2\sqrt{3} - 3)/3$

Problemas Quentes □

1.  $L^2W^2, \frac{1}{4}L^2W^2$  3. (a)  $x = w/3$ , base =  $w/3$  (b) Sim  
9.  $\sqrt{6}/2, 3\sqrt{2}/2$

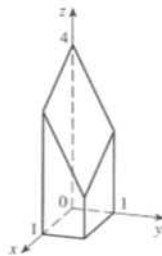
Capítulo 15

Exercícios 15.1 □

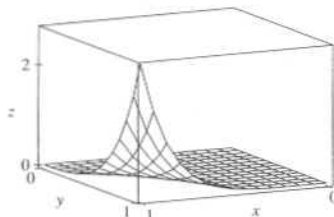
1. (a)  $-17,75$  (b)  $-15,75$  (c)  $-8,75$  (d)  $-6,75$   
3. (a) 63 (b) 43,5 5. (a)  $-6$  (b)  $-3,5$   
7.  $U < V < L$  9.  $\approx 248$  11. 60 13. 3  
15. 0,6065, 0,5694, 0,5606, 0,5585, 0,5579, 0,5578

Exercícios 15.2 □

1.  $9 + 27y, 8x + 24x^2$  3. 10 5. 1 7.  $\frac{4}{15}(31 - 9\sqrt{3})$   
9.  $\frac{21}{2} \ln 2$  11. 6 13.  $\frac{21}{2}$  15.  $9 \ln 2$   
17.  $[(\sqrt{3} - 1)/2] - (\pi/12)$  19.  $\ln \frac{27}{16}$   
21.



23. 37,5 25.  $\frac{166}{27}$  27.  $\frac{4}{15}(2\sqrt{2} - 1)$  29. 36  
31.  $21e - 57$  33.  $\frac{5}{6}$

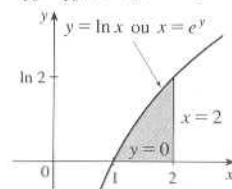
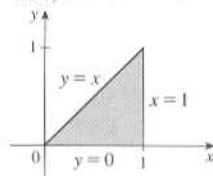


35. O teorema de Fubini não se aplica. O integrando tem uma descontinuidade infinita na origem.

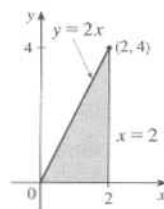
Exercícios 15.3 □

1.  $\frac{9}{20}$  3.  $\frac{4}{9}e^{3/2} - \frac{32}{45}$  5.  $e - 1$  7.  $\frac{256}{21}$  9.  $\frac{1}{2} \ln 2$   
11.  $\frac{1}{2}e^4 - 2e$  13.  $(1 - \cos 1)/2$  15.  $\frac{147}{20}$  17. 0  
19.  $\frac{6}{35}$  21.  $\frac{31}{8}$  23.  $\frac{1}{6}(11\sqrt{5} - 27) + \frac{9}{2} \sin^{-1} \frac{2}{3}$  25.  $\frac{1}{6}$   
27.  $\frac{1}{3}$  29. 0, 1,213, 0,713 31. 13.984.735.616/14.549.535

33.  $\int_0^1 \int_y^1 f(x, y) dx dy$  35.  $\int_0^{\ln 2} \int_{e^y}^2 f(x, y) dx dy$



37.  $\int_0^2 \int_0^{2x} f(x, y) dy dx$



39.  $(e^9 - 1)/6$     41.  $\frac{1}{4} \text{sen} 81$     43.  $(2\sqrt{2} - 1)/3$     45. 1  
 47.  $0 \leq \iint_D \sqrt{x^2 + y^2} dA \leq \sqrt{2}$     51.  $8\pi$     53.  $2\pi/3$

**Exercícios 15.4** □

1.  $\int_0^{2\pi} \int_0^2 f(r \cos \theta, r \text{sen} \theta) r dr d\theta$     3.  $\int_{-2}^2 \int_x^2 f(x, y) dy dx$   
 5.  $\int_0^{2\pi} \int_2^5 f(r \cos \theta, r \text{sen} \theta) r dr d\theta$     7. 0    9.  $\frac{609}{8}$   
 11.  $(\pi/2)(1 - e^{-4})$     13.  $24\pi^5$     15.  $\pi/12$     17. 4  
 19.  $81\pi/2$     21.  $\frac{4}{3}\pi a^3$     23.  $(2\pi/3)[1 - (1/\sqrt{2})]$   
 25.  $(8\pi/3)(64 - 24\sqrt{3})$     27.  $(\pi/4)(e - 1)$     29.  $4\pi/3$   
 31.  $1800\pi \text{ pês}^3$     33.  $\frac{15}{16}$     35. (a)  $\sqrt{\pi}/4$     (b)  $\sqrt{\pi}/2$

**Exercícios 15.5** □

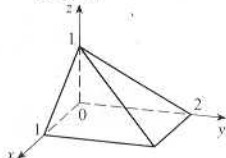
1.  $\frac{50}{3} C$     3.  $\frac{2}{3}, (0, \frac{1}{2})$     5.  $6, (\frac{3}{4}, \frac{3}{2})$     7.  $\frac{1}{6}, (\frac{4}{7}, \frac{3}{4})$   
 9.  $\frac{27}{2}, (\frac{8}{5}, \frac{1}{2})$     11.  $(\frac{3}{8}, 3\pi/16)$   
 13.  $(2a/5, 2a/5)$  se o vértice for  $(0, 0)$  e os lados estão ao longo dos eixos positivos.  
 15.  $\frac{1}{10}, \frac{1}{16}, \frac{13}{80}$     17.  $\frac{189}{20}, \frac{1269}{28}, \frac{1917}{35}$   
 19.  $m = \pi^2/8, (\bar{x}, \bar{y}) = (\frac{2\pi}{3} - \frac{1}{\pi}, \frac{16}{9\pi})$ ,  $I_x = 3\pi^2/64$ ,  
 $I_y = (\pi^4 - 3\pi^2)/16, I_0 = \pi^4/16 - 9\pi^2/64$   
 21.  $\rho a^4/3, \rho a^4/3; a/\sqrt{3}, a/\sqrt{3}$   
 23. (a)  $\frac{1}{2}$     (b) 0,375    (c)  $\frac{5}{48} \approx 0,1042$   
 25. (b) (i)  $e^{-0.2} \approx 0,8187$   
 (ii)  $1 + e^{-1.8} - e^{-0.8} - e^{-1} \approx 0,3481$     (c) 2, 5  
 27.  $\approx 0,500$   
 29. (a)  $\iint_D (k/20)[20 - \sqrt{(x-x_0)^2 + (y-y_0)^2}] dA$ , onde  $D$  é o disco com raio 10 mi centrado no centro da cidade.  
 (b)  $200\pi k/3 \approx 209k, 200(\pi/2 - \frac{8}{9})k \approx 136k$ , sobre a aresta

**Exercícios 15.6** □

1.  $15\sqrt{26}$     3.  $3\sqrt{14}$     5.  $12\text{sen}^{-1} \frac{2}{3}$   
 7.  $(\pi/6)(17\sqrt{17} - 5\sqrt{5})$     9.  $(2\pi/3)(2\sqrt{2} - 1)$   
 11.  $a^2(\pi - 2)$     13. (a)  $\approx 1,83$     (b)  $\approx 1,8616$   
 15.  $\frac{3}{2} + \frac{5}{8} \ln 5$     17. 3,3213    21.  $(\pi/6)(101\sqrt{101} - 1)$

**Exercícios 15.7** □

3. 1    5.  $\frac{1}{3}(e^3 - 1)$     7. 4    9.  $\frac{65}{28}$     11.  $\frac{1}{10}$     13.  $\frac{1}{12}$   
 15.  $16\pi/3$     17. 8    19.  $\frac{8}{15}$   
 21. (a)  $\int_0^1 \int_0^1 \int_0^{\sqrt{1-y^2}} dz dy dx$     (b)  $\frac{1}{4}\pi - \frac{1}{3}$   
 23.



25.  $\int_{-2}^2 \int_0^6 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} f(x, y, z) dz dy dx$   
 $= \int_0^6 \int_{-2}^2 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} f(x, y, z) dz dx dy$   
 $= \int_{-2}^2 \int_0^6 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} f(x, y, z) dx dy dz$   
 $= \int_0^6 \int_{-2}^2 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} f(x, y, z) dx dz dy$   
 $= \int_{-2}^2 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} \int_0^6 f(x, y, z) dy dz dx$   
 $= \int_{-2}^2 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} \int_0^6 f(x, y, z) dy dx dz$

27.  $\int_{-1}^1 \int_0^{1-x^2} \int_0^y f(x, y, z) dz dy dx$   
 $= \int_0^1 \int_{-\sqrt{1-y}}^{\sqrt{1-y}} \int_0^y f(x, y, z) dz dx dy$   
 $= \int_0^1 \int_2^1 \int_{-\sqrt{1-y}}^{\sqrt{1-y}} f(x, y, z) dx dy dz$   
 $= \int_0^1 \int_0^y \int_{-\sqrt{1-y}}^{\sqrt{1-y}} f(x, y, z) dx dz dy$   
 $= \int_{-1}^1 \int_0^{1-x^2} \int_2^1 f(x, y, z) dy dz dx$   
 $= \int_0^1 \int_{-\sqrt{1-z}}^{\sqrt{1-z}} \int_2^1 f(x, y, z) dy dx dz$

29.  $\int_0^1 \int_1^x \int_0^{1-y} f(x, y, z) dz dy dx = \int_0^1 \int_0^y \int_0^{1-y} f(x, y, z) dz dx dy$   
 $= \int_0^1 \int_0^{1-z} \int_0^y f(x, y, z) dx dy dz = \int_0^1 \int_0^{1-z} \int_0^y f(x, y, z) dx dz dy$   
 $= \int_0^1 \int_0^{-\sqrt{x}} \int_{\sqrt{x}}^1 f(x, y, z) dy dz dx = \int_0^1 \int_0^{(1-z)^2} \int_{\sqrt{x}}^1 f(x, y, z) dy dx dz$

31.  $\int_0^1 \int_0^x \int_0^y f(x, y, z) dz dy dx = \int_0^1 \int_2^1 \int_0^1 f(x, y, z) dx dy dz$   
 $= \int_0^1 \int_0^y \int_1^x f(x, y, z) dx dz dy = \int_0^1 \int_0^x \int_2^1 f(x, y, z) dy dz dx$   
 $= \int_0^1 \int_2^1 \int_0^x f(x, y, z) dy dx dz$

33.  $\frac{79}{30}, (\frac{338}{553}, \frac{33}{79}, \frac{571}{553})$     35.  $a^5, (7a/12, 7a/12, 7a/12)$

37. (a)  $m = \int_{-1}^1 \int_{-\sqrt{1-y^2}}^{\sqrt{1-y^2}} \int_{4y^2+4z^2}^4 (x^2 + y^2 + z^2) dx dz dy$

(b)  $(\bar{x}, \bar{y}, \bar{z})$ , onde  
 $\bar{x} = (1/m) \int_{-1}^1 \int_{-\sqrt{1-y^2}}^{\sqrt{1-y^2}} \int_{4y^2+4z^2}^4 x(x^2 + y^2 + z^2) dx dz dy$

$\bar{y} = (1/m) \int_{-1}^1 \int_{-\sqrt{1-y^2}}^{\sqrt{1-y^2}} \int_{4y^2+4z^2}^4 y(x^2 + y^2 + z^2) dx dz dy$

$\bar{z} = (1/m) \int_{-1}^1 \int_{-\sqrt{1-y^2}}^{\sqrt{1-y^2}} \int_{4y^2+4z^2}^4 z(x^2 + y^2 + z^2) dx dz dy$

(c)  $\int_{-1}^1 \int_{-\sqrt{1-y^2}}^{\sqrt{1-y^2}} \int_{4y^2+4z^2}^4 (x^2 + y^2)(x^2 + y^2 + z^2) dx dz dy$

39. (a)  $\frac{3}{32}\pi + \frac{11}{24}$     (b)  $(\bar{x}, \bar{y}, \bar{z})$ , onde  $\bar{x} = 28/(9\pi + 44)$ ,

$\bar{y} = 2(15\pi + 64)/[5(9\pi + 44)]$ ,  $\bar{z} = (45\pi + 208)/[15(9\pi + 44)]$

(c)  $(68 + 15\pi)/240$

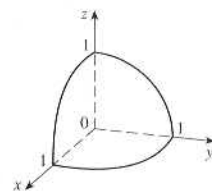
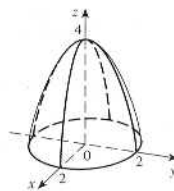
41.  $I_x = I_y = I_z = \frac{2}{3}kL^5$     43. (a)  $\frac{1}{8}$     (b)  $\frac{1}{64}$     (c)  $\frac{1}{5760}$

45.  $L^3/8$

47. A região limitada pelo elipsóide  $x^2 + 2y^2 + 3z^2 = 1$

**Exercícios 15.8** □

1.  $8\pi$     3.  $\pi/6$



sen

5.  $\int_0^{\pi/2} \int_0^3 \int_0^2 f(r \cos \theta, r \text{sen} \theta, z) r dz dr d\theta$     7. 384  
 9. 0    11.  $2\pi/5$     13.  $162\pi$     15.  $\pi K a^2/8, (0, 0, 2a/3)$   
 17.  $4\pi/5$     19.  $15\pi/16$     21.  $4\pi(2 - \sqrt{3})$     23.  $10\pi$   
 25.  $(0, 0, 2, 1)$     27. (a)  $(0, 0, \frac{3}{8}a)$     (b)  $4K\pi a^5/15$   
 29.  $(2\pi/3)[1 - (1/\sqrt{2})], (0, 0, 3/[8(2 - \sqrt{2})])$     31.  $5\pi/6$   
 33.  $8\pi/35$     35.  $243\pi/5$     37.  $136\pi/99$

**Exercícios 15.9** □

1. -14    3. 0    5.  $2uvw$   
 7. O paralelogramo com vértices  $(0, 0), (6, 3), (12, 1), (6, -2)$   
 9. A região limitada pelas retas  $y = 1$ , o eixo  $y$ , e  $y = \sqrt{x}$   
 11.  $\frac{11}{3}$     13.  $6\pi$     15.  $2 \ln 3$   
 17.  $(\text{sen}^4 abc)$     (b)  $1,083 \times 10^{12} \text{ km}^3$     19.  $-\frac{66}{125}$   
 21.  $\frac{3}{2} \sin 1$     23.  $e - e^{-1}$

Capítulo 15 Revisão □

Testes Falso-Verdadeiro

1. Verdadeiro 3. Verdadeiro 5. Falso

Exercícios

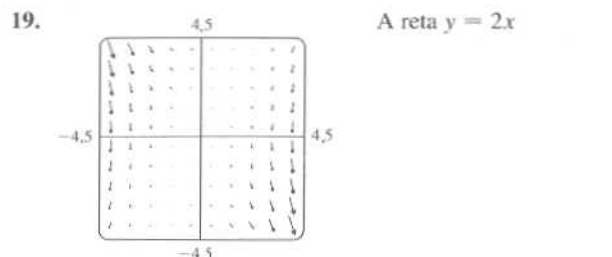
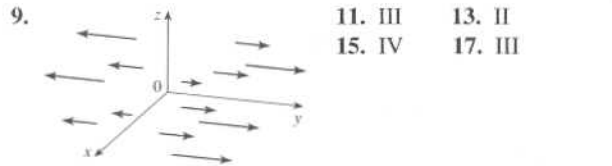
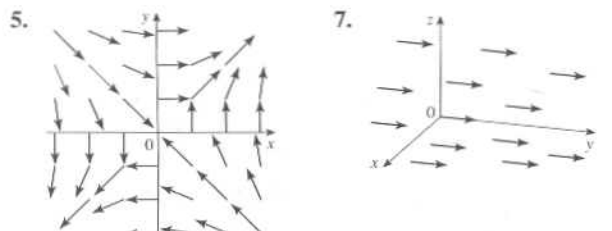
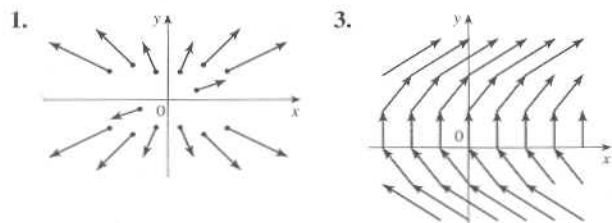
1.  $\approx 64,0$  3.  $4e^2 - 4e + 3$  5.  $\frac{1}{2} \sin 1$  7.  $\frac{2}{3}$   
 9.  $\int_0^\pi \int_2^4 f(r \cos \theta, r) r dr d\theta$   
 11. A região externa do círculo  $r = 1$  e interna do cardióide  $r = 1 + \sin \theta$   
 13.  $(e - 1)/2$  15.  $\ln \frac{3}{2}$  17.  $\frac{1}{40}$  19.  $\frac{41}{30}$  21.  $81\pi/5$   
 23.  $\frac{32}{3}$  25.  $\pi/96$  27.  $\frac{64}{15}$  29. 176 31.  $\frac{2}{3}$   
 33.  $2ma^3/9$   
 35. (a)  $\frac{1}{4}$  (b)  $(\frac{1}{3}, \frac{8}{15})$   
 (c)  $I_x = \frac{1}{12}, I_y = \frac{1}{24}; \bar{y} = 1/\sqrt{3}, \bar{x} = 1/\sqrt{6}$   
 37. (a)  $(0, 0, h/4)$  (b)  $\pi a^4 h/10$  39.  $\ln(\sqrt{2} + \sqrt{3}) + \sqrt{2}/3$   
 41.  $(\pi/8) \ln 5$  43. 0,0512 45. (a)  $\frac{1}{15}$  (b)  $\frac{1}{3}$  (c)  $\frac{1}{45}$   
 47.  $\int_0^1 \int_0^{1-z} \int_{-\sqrt{z}}^{\sqrt{z}} f(x, y, z) dx dy dz$  49.  $-\ln 2$  51. 0

Problemas Quentes □

1. 30 3.  $\frac{1}{2} \sin 1$  7. (b) 0,90

Capítulo 16

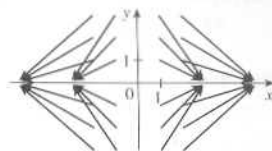
Exercícios 16.1 □



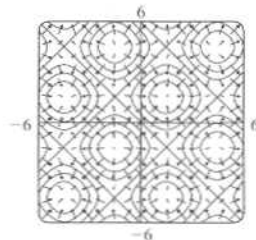
21.  $\nabla f(x, y) = \frac{1}{x + 2y} \mathbf{i} + \frac{2}{x + 2y} \mathbf{j}$

23.  $\nabla f(x, y, z) = \frac{x}{\sqrt{x^2 + y^2 + z^2}} \mathbf{i} + \frac{y}{\sqrt{x^2 + y^2 + z^2}} \mathbf{j} + \frac{z}{\sqrt{x^2 + y^2 + z^2}} \mathbf{k}$

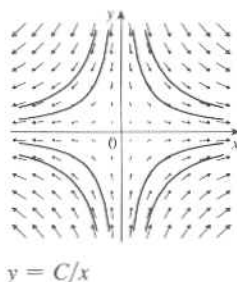
25.  $\nabla f(x, y) = 2x \mathbf{i} - y \mathbf{j}$



27. 29. IV 31. II

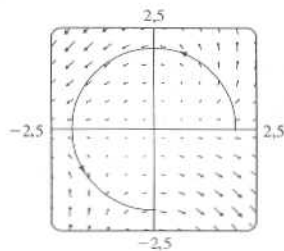


33. (a) (b)  $y = 1/x, x > 0$

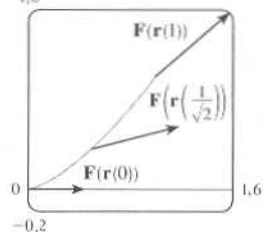


Exercícios 16.2 □

1.  $(17\sqrt{17} - 1)/12$  3. 1638,4 5.  $\frac{464}{3} + 9 \ln 3$  7.  $\frac{17}{3}$   
 9. 320 11.  $\sqrt{14}(e^6 - 1)/12$  13.  $\frac{16}{11}$  15.  $\frac{77}{6}$   
 17. (a) Positivo (b) Negativo 19.  $-\frac{59}{105}$   
 21.  $\frac{6}{5} - \cos 1 - \sin 1$   
 23.  $3\pi + \frac{2}{3}$



25. (a)  $\frac{11}{8} - 1/e$  (b) 1,6



27.  $\frac{945}{16,777,216} \pi$     29. 0,052    31.  $2\pi k, (4/\pi, 0)$   
 33. (a)  $\bar{x} = (1/m) \int_C x \rho(x, y, z) ds$ ,  
 $\bar{y} = (1/m) \int_C y \rho(x, y, z) ds$ ,  
 $\bar{z} = (1/m) \int_C z \rho(x, y, z) ds$ , onde  $m = \int_C \rho(x, y, z) ds$   
 (b)  $2\sqrt{13} k\pi, (0, 0, 3\pi)$   
 35.  $I_x = k((\pi/2) - \frac{2}{3})$ ,  $I_y = k((\pi/2) - \frac{2}{3})$   
 37.  $2\pi^2$     39.  $\frac{23}{88}$     41.  $1,67 \times 10^4$  pés-lb    43.  $\approx 22$  J

**Exercícios 16.3** □

1. 40    3.  $f(x, y) = 3x^2 + 5xy + 2y^2 + K$   
 5. Não conservativo    7.  $f(x, y) = x^2 \cos y - y \operatorname{sen} x + K$   
 9.  $f(x, y) = ye^x + x \operatorname{sen} y + K$     11. (b) 16  
 13. (a)  $f(x, y) = \frac{1}{4} x^4 y^4$     (b) 4  
 15. (a)  $f(x, y, z) = xy + yz$     (b) 15  
 17. (a)  $f(x, y, z) = x^2 z + x \operatorname{sen} y$     (b)  $2\pi$   
 19.  $25 \operatorname{sen} 1 - 1$     21.  $\frac{8}{3}$     23. Não    25. Não  
 29. (a) Sim    (b) Sim    (c) Sim  
 31. (a) Sim    (b) Sim    (c) Não

**Exercícios 16.4** □

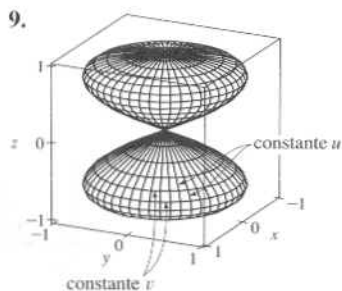
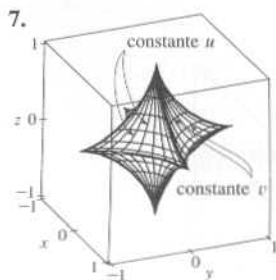
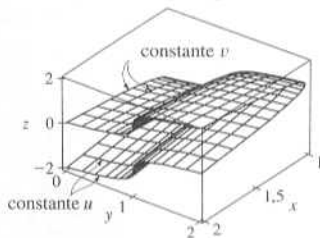
1. 6    3.  $\frac{2}{3}$     7.  $e - 1$     9.  $\frac{1}{3}$     11.  $-24\pi$     13. 0  
 15.  $\pi + \frac{16}{3} [(1/\sqrt{2}) - 1]$     17.  $-\frac{1}{12}$     19.  $3\pi/8$   
 21. (c)  $\frac{9}{2}$     23.  $(\frac{1}{3}, \frac{1}{3})$

**Exercícios 16.5** □

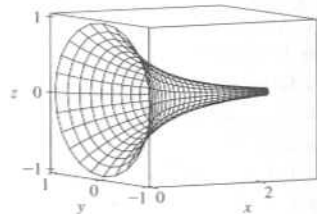
1. (a)  $-y \mathbf{i} - z \mathbf{j} - x \mathbf{k}$     (b)  $x + y + z$   
 3. (a)  $-x^2 \mathbf{i} + 3xy \mathbf{j} - xz \mathbf{k}$     (b)  $yz$     5. (a) 0    (b) 1  
 7. (a)  $\frac{y}{z^2} \mathbf{i} - \frac{x}{z^2} \mathbf{j}$     (b)  $\frac{2z + 1}{z^2}$   
 9. (a) Negativo    (b)  $\operatorname{rot} \mathbf{F} = \mathbf{0}$   
 11. (a) Zero    (b)  $\operatorname{rot} \mathbf{F}$  pontos na direção do eixo  $z$  no sentido negativo  
 13.  $f(x, y, z) = xyz + K$     15.  $f(x, y, z) = x^2 y + y^2 z + K$   
 17. Não conservativo    19. Não

**Exercícios 16.6** □

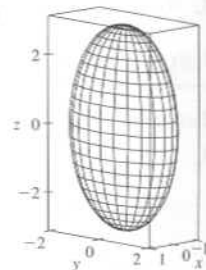
1. Parabolóide circular tendo por eixo o eixo  $z$   
 3. Cilindro circular tendo por eixo o eixo  $x$   
 5.



11. IV    13. I    15. II  
 17.  $x = 1 + u + v, y = 2 + u - v, z = -3 - u + v$   
 19.  $x = x, y = 6 - 3x^2 - 2z^2, z = z, 3x^2 + 2z^2 \leq 6$   
 21.  $x = 2 \operatorname{sen} \phi \cos \theta, y = 2 \operatorname{sen} \phi \operatorname{sen} \theta,$   
 $z = 2 \cos \phi, 0 \leq \phi \leq \pi/4, 0 \leq \theta \leq 2\pi$   
 23.  $x = r \cos \theta, y = r \operatorname{sen} \theta, z = 5, 0 \leq r \leq 4, 0 \leq \theta \leq 2\pi$   
 [or  $x = x, y = y, z = 5, x^2 + y^2 \leq 16$ ]  
 25.  $x = x, y = e^{-x} \cos \theta,$   
 $z = e^{-x} \operatorname{sen} \theta, 0 \leq x \leq 3,$   
 $0 \leq \theta \leq 2\pi$



27. (a) Sentidos reversos    (b) Números de espirais duplas  
 29.  $3x - y + 3z = 3$     31.  $x = 0$   
 33.  $4\sqrt{6} \pi$     35.  $(\pi/6)(17\sqrt{17} - 5\sqrt{5})$   
 37.  $(\sqrt{21}/2) + \frac{17}{4} [\ln(2 + \sqrt{21}) - \ln \sqrt{17}]$   
 39.  $2a^2(\pi - 2)$     41.  $\pi(2\sqrt{6} - \frac{8}{3})$   
 43. (a)  $\approx 1,83$     (b)  $\approx 1,8616$     45. (b)



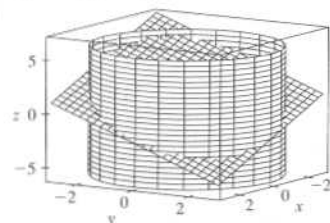
- (c)  $\int_0^{2\pi} \int_0^{\pi/2} \sqrt{36 \operatorname{sen}^4 u \cos^2 v + 9 \operatorname{sen}^4 u \operatorname{sen}^2 v + 4 \cos^2 u \operatorname{sen}^2 u} du dv$   
 47. 4,4506

**Exercícios 16.7** □

1.  $8(1 + \sqrt{2} + \sqrt{3}) \approx 33,17$     3.  $900\pi$   
 5.  $171\sqrt{14}$     7.  $\sqrt{3}/24$     9.  $(33\sqrt{33} - 17\sqrt{17})/6$   
 11.  $\pi\sqrt{2}/4$     13.  $16\pi$     15.  $16\pi$     17. 0    19.  $\frac{713}{180}$   
 21.  $-\frac{1}{6}$     23.  $108\pi$     25. 0    27. 48    29. 0,1642  
 31. 3,4895  
 33.  $\iint_S \mathbf{F} \cdot d\mathbf{S} = \iint_D [P(\partial h/\partial x) - Q + R(\partial h/\partial z)] dA$ ,  
 onde  $D =$  projeção sobre o plano  $xz$   
 35.  $(0, 0, a/2)$   
 37. (a)  $I_z = \iint_S (x^2 + y^2) \rho(x, y, z) dS$   
 (b)  $4329\sqrt{2} \pi/5$   
 39.  $194.400\pi$     41.  $8\pi a^3 \epsilon_0/3$     43.  $1248\pi$

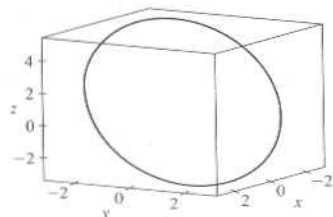
**Exercícios 16.8** □

3. 0    5. 0    7. -1    9. -4\pi  
 11. (a)  $81\pi/2$     (b)





(c)  $x = 3 \cos t, y = 3 \sin t,$   
 $z = 1 - 3(\cos t + \sin t),$   
 $0 \leq t \leq 2\pi$



17. 16

**Exercícios 16.9** □

1. Negativo em  $P_1$ , positivo em  $P_2$     7. 8    9. 0  
 11.  $9\pi/2$     13.  $12\pi/5$     15.  $-81\pi/2$   
 17.  $341\sqrt{2}/60 + \frac{81}{20} \arcsen(\sqrt{3}/3)$     19.  $13\pi/20$

**Capítulo 16 Revisão** □

**Testes Falso-Verdadeiro**

1. Falso    3. Verdadeiro    5. Falso    7. Verdadeiro

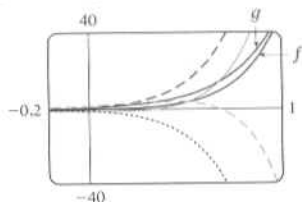
**Exercícios**

1. (a) Negativo    (b) Positivo    3.  $4\sqrt{5}$     5.  $-\pi$     7.  $\frac{17}{2}$   
 9. 5    11.  $f(x, y) = x \sin y - \cos y$     13.  $\pi^2$     17.  $-8\pi$   
 25.  $\frac{1}{6}(27 - 5\sqrt{5})$     27.  $\pi(391\sqrt{17} + 1)/60$   
 29.  $-64\pi/3$     33.  $-\frac{1}{2}$     37.  $-4$     39. 21

**Capítulo 17**

**Exercícios 17.1** □

1.  $y = c_1 e^{4x} + c_2 e^{2x}$     3.  $y = e^{-4x}(c_1 \cos 5x + c_2 \sin 5x)$   
 5.  $y = c_1 e^x + c_2 x e^x$     7.  $y = c_1 \cos(x/2) + c_2 \sin(x/2)$   
 9.  $y = c_1 + c_2 e^{-x/4}$     11.  $y = c_1 e^{(1+\sqrt{2})x} + c_2 e^{(1-\sqrt{2})x}$   
 13.  $y = e^{-t/2}[c_1 \cos(\sqrt{3}t/2) + c_2 \sin(\sqrt{3}t/2)]$   
 15.



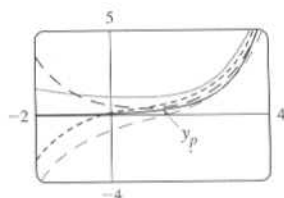
Todas as soluções aproximam-se de 0 quando  $x \rightarrow -\infty$  e aproximam-se de  $\pm\infty$  quando  $x \rightarrow \infty$ .

17.  $y = 2e^{-3x/2} + e^{-x}$     19.  $y = e^x(\cos x + \sin x)$   
 21.  $y = 2e^{1-x} + e^{3(x-1)}$     23.  $y = -\frac{1}{3} \sin 3x$   
 25.  $y = 3xe^{-2x+2}$     27. Sem solução  
 29.  $y = \frac{e^5}{e^6 - 1} e^{-x} + \frac{e^2}{1 - e^6} e^{2x}$   
 31.  $y = e^{-2x}(2 \cos 3x - e^x \sin 3x)$   
 33. (b)  $\lambda = n^2 \pi^2 / L^2, n$  um inteiro positivo;  $y = C \sin(n\pi x / L)$

**Exercícios 17.2** □

1.  $y = c_1 e^{-2x} + c_2 e^{-x} + \frac{1}{2} x^2 - \frac{3}{2} x + \frac{7}{4}$   
 3.  $y = c_1 + c_2 e^{2x} + \frac{1}{40} \cos 4x - \frac{1}{20} \sin 4x$   
 5.  $y = e^{2x}(c_1 \cos x + c_2 \sin x) + \frac{1}{10} e^{-x}$   
 7.  $y = \frac{3}{2} \cos x + \frac{11}{2} \sin x + \frac{1}{2} e^x + x^3 - 6x$   
 9.  $y = \frac{5}{8} e^x - \frac{17}{32} e^{-x} + e^{2x}[\frac{1}{8} x - \frac{3}{32}]$

11.

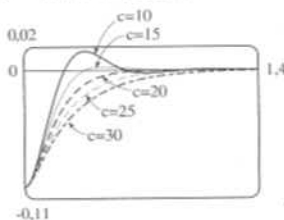


As soluções são todas assintóticas a  $y_p = e^x/10$  quando  $x \rightarrow \infty$ . Exceto para  $y_p$ , todas as soluções aproximam-se ou de  $\infty$  ou de  $-\infty$  quando  $x \rightarrow -\infty$ .

13.  $y_p = (Ax^4 + Bx^3 + Cx^2 + Dx + E)e^{2x}$   
 15.  $y_p = xe^x(A \cos x + B \sin x)$   
 17.  $y = c_1 \cos 2x + c_2 \sin 2x + \frac{1}{4} x$   
 19.  $y = c_1 e^x + c_2 x e^x + e^{2x}$   
 21.  $y = (c_1 + x) \sin x + (c_2 + \ln \cos x) \cos x$   
 23.  $y = [c_1 + \ln(1 + e^{-x})]e^x + [c_2 - e^{-x} + \ln(1 + e^{-x})]e^{2x}$   
 25.  $y = [c_1 - \frac{1}{2} \int (e^x/x) dx]e^{-x} + [c_2 + \frac{1}{2} \int (e^{-x}/x) dx]e^x$

**Exercícios 17.3** □

1.  $x = 0,36 \sin(10t/3)$     3.  $x = -\frac{1}{5} e^{-6t} + \frac{6}{5} e^{-t}$     5.  $\frac{49}{12}$  kg  
 7.



11.  $Q(t) = (-e^{-10t}/250)(6 \cos 20t + 3 \sin 20t) + \frac{3}{125},$   
 $I(t) = \frac{3}{5} e^{-10t} \sin 20t$   
 13.  $Q(t) = e^{-10t}[\frac{3}{250} \cos 20t - \frac{3}{500} \sin 20t]$   
 $-\frac{3}{250} \cos 10t + \frac{3}{125} \sin 10t$

**Exercícios 17.4** □

1.  $c_0 \sum_{n=0}^{\infty} \frac{x^n}{n!} = c_0 e^x$     3.  $c_0 \sum_{n=0}^{\infty} \frac{x^{3n}}{3^n n!} = c_0 e^{x^3/3}$   
 5.  $c_0 \sum_{n=0}^{\infty} \frac{(-1)^n}{2^n n!} x^{2n} + c_1 \sum_{n=0}^{\infty} \frac{(-2)^n n!}{(2n+1)!} x^{2n+1}$   
 7.  $c_0 + c_1 x + c_0 \frac{x^2}{2} + c_0 \sum_{n=2}^{\infty} \frac{(-1)^{n-1} (2n-3)!}{2^{2n-2} n! (n-2)!} x^{2n}$   
 9.  $\sum_{n=0}^{\infty} \frac{x^{2n}}{2^n n!} = e^{x^2/2}$   
 11.  $x + \sum_{n=1}^{\infty} \frac{(-1)^n 2^2 5^2 \cdots (3n-1)^2}{(3n+1)!} x^{3n+1}$

**Capítulo 17 Revisão** □

**Testes Falso-Verdadeiro**

1. Verdadeiro    3. Verdadeiro

**Exercícios**

1.  $y = c_1 e^{5x} + c_2 e^{-3x}$     3.  $y = c_1 \cos(\sqrt{3}x) + c_2 \sin(\sqrt{3}x)$   
 5.  $y = e^{-x}(c_1 + c_2 x) - \frac{3}{50} \cos 3x - \frac{2}{25} \sin 3x$   
 7.  $y = c_1 \cos(3x/2) + c_2 \sin(3x/2) + \frac{2}{5} x^2 - \frac{43}{81}$   
 9.  $y = c_1 e^x + c_2 e^{2x} + x e^{2x}$     11.  $y = 5 - 2e^{-6(x-1)}$   
 13.  $y = (e^{4x} - e^x)/3$     15.  $\sum_{n=0}^{\infty} \frac{(-2)^n n!}{(2n+1)!} x^{2n+1}$   
 17.  $Q(t) = -0,02e^{-10t}(\cos 10t + \sin 10t) + 0,03$   
 19. (c)  $2\pi/k \approx 85$  min    (d)  $\approx 17.600$  mi/h