

Respostas aos Problemas Pares

CAPÍTULO 2

- 2.2. $707\text{ N} \angle 58,6^\circ$.
 2.4. $17,0 \text{ kN} \nearrow 84,8^\circ$.
 2.6. $19,0^\circ$
 2.8. (a) 585 N . (b) 896 N .
 2.10. (a) $78,9 \text{ N}$. (b) 169 N .
 2.12. $P = 72, 1 \text{ N}$; $\alpha = 44,7^\circ$.
 2.14. $414\text{ N} \sphericalangle 72,0^\circ$.
 2.16. $(45\text{ N}) 25,8 \text{ N}$, $+ 36,9 \text{ N}$;
 $(60\text{ N}) +49,1 \text{ N}$, $+34,4 \text{ N}$;
 $(75\text{ N}) +48,2 \text{ N}$, $- 57,5\text{ N}$.
 2.18. $(530\text{ N}) +450 \text{ N}$, $+280 \text{ N}$;
 $(510\text{ N}) - 240 \text{ N}$, $+450 \text{ N}$.
 2.20. (a) 261 N . (b) -168 N .
 2.22. -120 N , $+350\text{ N}$.
 2.24. $(300 \text{ N}) 77,6 \text{ N}$, 290 N
 $(450 \text{ N}) 369 \text{ N}$, 258 N .
 2.26. $1,45 \text{ kN} \angle 78,4^\circ$.
 2.28. $760 \text{ N} \angle 74,0^\circ$.
 2.30. $25,6 \text{ kN}$.

- 2.32. (a) $36,9^\circ$. (b) 80 N .
 2.34. $T_{AC} = 352 \text{ N}$; $T_{BC} = 261 \text{ N}$.
 2.36. $T_{AC} = 265 \text{ N}$; $T_{BC} = 175 \text{ N}$.
 2.38. $T_{AC} = 326 \text{ N}$; $T_{BC} = 369 \text{ N}$.
 2.40. $T_A = 231 \text{ N}$; $T_B = 577 \text{ N}$.
 2.42. $T_{AB} = 600 \text{ N}$; $T_{AC} = 344 \text{ N}$.
 2.44. (a) $\alpha = 35^\circ$; $T_{AC} = 410 \text{ N}$; $T_{BC} = 287 \text{ N}$. (b) $\alpha = 55^\circ$; $T_{AC} = T_{BC} = 305 \text{ N}$.
 2.46. $0,75\text{ m}$.
 2.48. (a) $1,47 \text{ kN}$. (b) $1,47 \text{ kN}$. (c) 981 N . (d) 981 N . (e) 736 N .
 2.50. $913 \text{ N} \sphericalangle 82,5^\circ$.
 2.52. (a) 80 N . (b) 285 N .
 2.54. (a) $+278 \text{ N}$, $+383 \text{ N}$, $+161 \text{ N}$.
 (b) $56,2^\circ$, $40,0^\circ$, $71,3^\circ$.
 2.56. (a) -176 N , -257 N , $+251 \text{ N}$.
 (b) 116° , 130° , $51,1^\circ$.
 2.58. (a) $-9 305 \text{ N}$, $+16 800 \text{ N}$, $+3 385 \text{ N}$.
 (b) $118,5^\circ$, $30,5^\circ$, $80,0^\circ$.
 2.60. $1,05 \text{ kN}$; $51,8^\circ$; 108° ; 136° .
 2.62. (a) $F_x = 538,5 \text{ N}$, $F_z = 1 335 \text{ N}$;
 $F = 2080 \text{ N}$. (b) $43,9^\circ$.
 2.64. $-6,30 \text{ kN}$, $+6,06 \text{ kN}$, $+4,86 \text{ kN}$.
 2.66. $-1 125 \text{ N}$, $+750 \text{ N}$, $+450 \text{ N}$.
 2.68. $R = 3 115 \text{ N}$; $\theta_x = 37,4^\circ$, $\theta_y = 122,0^\circ$, $\theta_z = 72,6^\circ$.
 2.70. $R = 498 \text{ N}$; $\theta_x = 68,9^\circ$, $\theta_y = 26,3^\circ$, $\theta_z = 75,1^\circ$.
 2.72. 510 N .
 2.74. $10,1 \text{ kN}$.
 2.76. $9,32 \text{ kN}$.
 2.78. $T_{AB} = 500 \text{ N}$; $T_{AC} = 459 \text{ N}$; $T_{AD} = 516 \text{ N}$.
 2.80. $T_{AB} = 2,88 \text{ kN}$; $T_{AC} = 5,76 \text{ kN}$; $T_{AD} = 3,60 \text{ kN}$.
 2.82. $T_{AB} = T_{AC} = 16,75 \text{ N}$; $T_{AD} = 29,0 \text{ N}$.
 2.84. $T_{AB} = 158,5 \text{ N}$; $T_{AC} = 321,5 \text{ N}$.
 2.86. $H = 138 \text{ N}$; $T_{AB} = 270 \text{ N}$; $T_{AC} = 196 \text{ N}$.
 2.88. $H = 131 \text{ N}$; $Q = 28,6 \text{ N}$. $T_{AB} = T_{AC} = 220 \text{ N}$.
 2.90. $T_{BAC} = 288 \text{ N}$; $T_{AD} = 100,5 \text{ N}$; $T_{AE} = 184,5 \text{ N}$.
 2.92. 605 mm .

- 2.94. $x = 67 \text{ mm}$, $z = 134 \text{ mm}$.
 2.96. (a) 991 N . (b) 973 N .
 2.98. $314 \text{ N} \leq P \leq 1 290 \text{ N}$.
 2.100. $141,5^\circ$, $124,4^\circ$, $74,9^\circ$.
 2.102. $179 \text{ N} < P < 669 \text{ N}$.
 2.104. (a) $1 685 \text{ N} \sphericalangle 10,7^\circ$. (b) $1480 \text{ N} \sphericalangle 3,1^\circ$.
 2.106. $T_{AD} = 200 \text{ N}$; $T_{BD} = T_{CD} = 170 \text{ N}$.

CAPÍTULO 3

- 3.2. $16,4^\circ$.
 3.4. $116 \text{ N} \cdot \text{m}$.
 3.6. (a) $27,4 \text{ N} \cdot \text{m}$. (b) $228 \text{ N} \searrow 42,0^\circ$.
 3.8. $18,5 \text{ N} \cdot \text{m}$.
 3.10. 772 N .
 3.12. $d = (xF_y - yF_x)/(F_x^2 + F_y^2)^{1/2}$.
 3.14. (a) $+3\mathbf{i} - 26\mathbf{j} - 18\mathbf{k}$. (b) 0 . (c) $-15\mathbf{i} - 20\mathbf{j}$.
 3.16. $(7,50 \text{ N} \cdot \text{m})\mathbf{i} - (6,00 \text{ N} \cdot \text{m})\mathbf{j} - (10,4 \text{ N} \cdot \text{m})\mathbf{k}$.
 3.18. $(267 \text{ N} \cdot \text{m})\mathbf{i} + (78,1 \text{ N} \cdot \text{m})\mathbf{j} - (202 \text{ N} \cdot \text{m})\mathbf{k}$.
 3.20. 101 mm .
 3.22. $2,81 \text{ m}$.
 3.24. 207 mm .
 3.26. $\mathbf{P} \cdot \mathbf{Q} = +1$; $\mathbf{P} \cdot \mathbf{S} = -11$; $\mathbf{Q} \cdot \mathbf{S} = +10$.
 3.28. $77,9^\circ$.
 3.30. $26,8^\circ$.
 3.32. (a) $59,1^\circ$. (b) 648 N .
 3.34. $+46$; $+46$; -46 .
 3.36. $M_x = 0$, $M_y = -162 \text{ N} \cdot \text{m}$, $M_z = +270 \text{ N} \cdot \text{m}$.
 3.38. 196 N .
 3.40. $P = 125 \text{ N}$; $\phi = 73,7^\circ$, $\theta = 53,1^\circ$.
 3.42. $-90,0 \text{ N} \cdot \text{m}$.
 3.44. $280 \text{ N} \cdot \frac{\text{m}}{\text{m}}$.
 3.46. $+Pa/\sqrt{2}$.

- 3.48. (b) $d = a / \sqrt{2}$.
- 3.50. 0,268 m.
- 3.52. 322 mm.
- 3.54. (a) 16,7 N. (b) 31,3 N. (c) 14,7 N.
- 3.56. 32 mm.
- 3.58. (a) $M = 13,6 \text{ N} \cdot \text{m}$; $\theta_x = 27,8^\circ$, $\theta_y = 62,2^\circ$, $\theta_z = 90^\circ$. (b) 18,2 N \searrow 62,2° em B e 18,2 N \swarrow 62,2° em C.
- 3.60. $M = 4\,750 \text{ N} \cdot \text{m}$; $\theta_x = 164^\circ$, $\theta_y = 92,9^\circ$, $\theta_z = 74,8^\circ$.
- 3.62. $\mathbf{F} = 1\,156 \text{ N} \nearrow 67,4^\circ$, $\mathbf{M} = 22,6 \text{ N} \cdot \text{m}$.
- 3.64. (a) $\mathbf{F} = 250 \text{ N} \searrow 25^\circ$, $\mathbf{M} = 57,5 \text{ N} \cdot \text{m}$.
(b) $\mathbf{A} = 375 \text{ N} \swarrow 25^\circ$, $\mathbf{B} = 625 \text{ N} \searrow 25^\circ$.
- 3.66. $\mathbf{F} = 750 \text{ N} \downarrow$ $x = 40 \text{ mm}$.
- 3.68. (a) 30°. (b) 65,7°.
- 3.70. $\mathbf{F} = -(1\,334 \text{ N})\mathbf{i} + (534 \text{ N})\mathbf{j} - (890 \text{ N})\mathbf{k}$;
 $\mathbf{M} = (4\,067 \text{ N} \cdot \text{m})\mathbf{j} + (2\,440 \text{ N} \cdot \text{m})\mathbf{k}$.
- 3.72. $\mathbf{F} = -(123 \text{ N})\mathbf{j} - (86,0 \text{ N})\mathbf{k}$;
 $\mathbf{M} = (22,6 \text{ N} \cdot \text{m})\mathbf{i} + (15,5 \text{ N} \cdot \text{m})\mathbf{j} - (22,1 \text{ N} \cdot \text{m})\mathbf{k}$.
- 3.74. Sistemas força-binário em D e C.
- 3.76. c e g.
- 3.78. (a) 500 N \downarrow ; 2,2 m, (b) 500 N \uparrow ; 1,0 m, (c) 500 N \downarrow ; 0,4 m.
- 3.80. (a) 457 mm. (b) 960 mm. (c) 1 692 mm.
- 3.82. (a) 1 739 N \swarrow 39,8°;
(b) 0,305 m para a direita de C e 0,254 m acima de C.
- 3.84. (a) 136 N \swarrow 28°. (b) 18,4 mm à direita de A e 50,0 mm acima de C.
- 3.86. (a) $\mathbf{R} = 3,2 \text{ kN} \rightarrow$, $\mathbf{M}_D^R = 22,8 \text{ kN} \cdot \text{m}$.
(b) $\mathbf{R} = 3,2 \text{ kN} \rightarrow$, 7,1 m abaixo de DE.
- 3.88. (a) $\mathbf{B} = -(80 \text{ N})\mathbf{k}$; $\mathbf{C} = (-30 \text{ N})\mathbf{i} + (40 \text{ N})\mathbf{k}$.
(b) $R_y = 0$, $R_z = -40 \text{ N}$. (c) Vertical.
- 3.90. (a) 60°. (b) $\mathbf{R} = (66,5 \text{ N})\mathbf{i} - (115 \text{ N})\mathbf{j}$
 $\mathbf{M}_C^R = (35,2 \text{ N} \cdot \text{m})\mathbf{i}$.
- 3.92. $\mathbf{R} = (66,5 \text{ N})\mathbf{i} - (115 \text{ N})\mathbf{j}$;
 $\mathbf{M}_E^R = (35,2 \text{ N} \cdot \text{m})\mathbf{i} + (9,4 \text{ N} \cdot \text{m})\mathbf{k}$.
(a) Aperta. (b) Afrouxa.

3.94. 333 kN em $x = +1,46 \text{ m}$ e $z = -0,424 \text{ m}$.

3.96. 140 kN; 0,714 m de A, na aresta AD.

3.98. (a) $\mathbf{R} = -(267 \text{ N})\mathbf{j}$. (b) -15,2 mm.
(c) $x = 0$, $z = 229 \text{ mm}$.

3.100. (a) - (40 N)j. (b) 2,5 mm.
(c) $x = -5 \text{ mm}$, $z = 0$.

3.102. (a) $-\frac{1}{2} P\mathbf{k}$. (b) $R = \frac{3}{2} P$, $\theta_x = \theta_y = 48,2^\circ$,
 $\theta_z = 109,5^\circ$, (c) $y = a$, $z = \frac{1}{2}a$.

3.104. (a) $R = 491 \text{ N}$; $\theta_x = 148,7^\circ$, $\theta_y = 95,8^\circ$,
 $\theta_z = 120,6^\circ$. (b) 16,4 mm.
(c) $x = +358 \text{ mm}$, $z = +138 \text{ mm}$.

3.106. (a) $\mathbf{R} = (178 \text{ N})\mathbf{i} + (133 \text{ N})\mathbf{j}$. (b) +76,7 mm.
(c) $x = 0$, $z = -68 \text{ mm}$.

3.112. 4,06 kN.

3.114. 4 075 N.

3.116. 132 N \cdot m] .

3.118. (a) 500 N \searrow 60°, 68,9 N \cdot m] .

(b) $\mathbf{A} = 689 \text{ N} \uparrow$; $\mathbf{B} = 1\,150 \text{ N} \searrow 77,4^\circ$.

3.120. 60,1 kN \downarrow , em $x = 4,99 \text{ m}$, $z = 3,33 \text{ m}$.

3.122. (a) $\mathbf{A} = 111 \text{ N} \downarrow$; $\mathbf{C} = 111 \text{ N} \uparrow$.
(b) $\mathbf{B} = 160 \text{ N} \searrow$; $\mathbf{D} = 160 \text{ N} \swarrow$.
(c) $\mathbf{A} = 103 \text{ N} \searrow$; $\mathbf{D} = 103 \text{ N} \swarrow$.

CAPÍTULO 4

4.2. (a) 117 N \uparrow (b) 392 N \uparrow .

4.4. (a) 64,6 kN. (b) 106,6 kN \uparrow .

4.6. 62,0°.

4.8. $0,5 \text{ kN} \leq Q \leq 11 \text{ kN}$.

4.10. $1 \text{ kN} \leq Q \leq 3,25 \text{ kN}$.

4.12. $\mathbf{A} = 489 \text{ N} \downarrow$; $\mathbf{C} = 669 \text{ N} \swarrow 81,4^\circ$.

4.14. 1150 N.

4.16. (a) $\mathbf{A} = 4,27 \text{ kN} \swarrow 20,6^\circ$; $\mathbf{B} = 4,50 \text{ kN} \uparrow$.

(b) $\mathbf{A} = 1,50 \text{ kN} \uparrow$; $\mathbf{B} = 6,02 \text{ kN} \swarrow 48,4^\circ$.

(c) $\mathbf{A} = 2,05 \text{ kN} \swarrow 47,0^\circ$; $\mathbf{B} = 5,20 \text{ kN} \swarrow 60,0^\circ$.

4.18. (a) $\mathbf{A} = 125 \text{ N} \downarrow$; $\mathbf{B} = 125 \text{ N} \uparrow$.

(b) $\mathbf{A} = 188 \text{ N} \leftarrow$; $\mathbf{B} = 188 \text{ N} \rightarrow$.

(c) $\mathbf{A} = 104 \text{ N} \nearrow 60^\circ$; $\mathbf{B} = 104 \text{ N} \searrow 60^\circ$.

4.20. $T_{BE} = 196,2 \text{ N}$; $\mathbf{A} = 73,6 \text{ N} \rightarrow$; $\mathbf{D} = 73,6 \text{ N} \leftarrow$.

4.22. $\mathbf{A} = 347 \text{ N} \rightarrow$; $\mathbf{B} = 173 \text{ N} \searrow 60^\circ$; $\mathbf{C} = 866 \text{ N} \swarrow 60^\circ$.

4.24. (a) 1,84 kN \rightarrow , (b) 1,25 kN $\nearrow 40^\circ$.

4.26. (a) 640 N, (b) $\mathbf{A} = 400 \text{ N} \uparrow$; $\mathbf{B} = 320 \text{ N} \rightarrow$.

4.28. (a) $\mathbf{M} = 7,23 \text{ N} \cdot \text{m}$] .

(b) $\mathbf{A}_x = 40,2 \text{ N} \rightarrow$; $\mathbf{A}_y = 150 \text{ N} \uparrow$.

4.30. $258 \text{ N} \leq T_2 \leq 790 \text{ N}$.

4.32. $\theta = \arctg(Q/3P)$.

4.34. (a) $\theta = 2 \arcsen(W/2P)$. (b) $\theta = 29,0^\circ$.

4.36. (a) $\theta = 2 \arcsen\left[\frac{kl}{2}/(kl - P)\right]$; (b) 83,6°.

4.38. (a) $y\left(1 - \frac{a}{\sqrt{a^2 + y^2}}\right) = \frac{P}{k}$. (b) 1,00 kN/m.

- 4.40. 1) Completamente vinculada; determinada;
 $\mathbf{A} = 60,1 \text{ kN} \searrow 56,3^\circ$; $\mathbf{B} = 33,4 \text{ kN} \leftarrow$.
- 2) Ineficazmente vinculada; indeterminada; não equilibrada.
- 3) Completamente vinculada; determinada; $\mathbf{A} = \mathbf{C} = 25 \text{ kN} \uparrow$.
- 4) Completamente vinculada; indeterminada;
 $\mathbf{A}_x = 33,4 \text{ kN} \rightarrow$; $\mathbf{B}_x = 33,4 \text{ kN} \leftarrow$;
 $(\mathbf{A}_y + \mathbf{B}_y = 50 \text{ kN} \uparrow)$.
- 5) Ineficazmente vinculada; indeterminada; não equilibrada.
- 6) Parcialmente vinculada; determinada; equilibrada;
 $\mathbf{A} = \mathbf{C} = 25 \text{ kN} \uparrow$.
- 7) Completamente vinculada; determinada;
 $\mathbf{A} = 25 \text{ kN} \uparrow$; $\mathbf{B} = 41,7 \text{ kN} \swarrow 36,9^\circ$;
 $\mathbf{C} = 33,4 \text{ kN} \rightarrow$.
- 8) Completamente vinculada; indeterminada;
 $\mathbf{A}_y = 25 \text{ kN} \uparrow$.

- 4.42. $\mathbf{A} = 2,23 \text{ kN} \searrow 7,73^\circ$; $\mathbf{B} = 2,21 \text{ kN} \rightarrow$.
- 4.44. $\mathbf{A} = 313 \text{ N} \searrow 53,1^\circ$; $\mathbf{B} = 188 \text{ N} \rightarrow$.
- 4.46. (a) $\mathbf{A} = P \sqrt{2} \searrow 45^\circ$; $\mathbf{B} = P \uparrow$.
(b) $\mathbf{A} = P/\sqrt{2} \leftarrow$; $\mathbf{B} = P/\sqrt{2} \uparrow$.
- 4.48. $\mathbf{A} = 413 \text{ N} \searrow 14,0^\circ$; $T = 500 \text{ N}$.
- 4.52. $\mathbf{A} = 170 \text{ N} \searrow 33,9^\circ$; $\mathbf{C} = 160 \text{ N} \searrow 28,1^\circ$.
- 4.54. (a) 600 N. (b) $\mathbf{C} = 750 \text{ N} \searrow 36,9^\circ$.
- 4.56. $\theta + \alpha = 90^\circ$.
- 4.58. (a) 225 mm. (b) 23,1 N. (c) 12,2 N.
- 4.60. $34,3^\circ$.
- 4.62. $\mathbf{A} = (150 \text{ N})\mathbf{j} - (14,5 \text{ N})\mathbf{k}$;
 $\mathbf{B} = (100 \text{ N})\mathbf{j} - (57,8 \text{ N})\mathbf{k}$; $\mathbf{C} = (72,2 \text{ N})\mathbf{k}$.
- 4.64. $\mathbf{A} = (104 \text{ N})\mathbf{j} + (128 \text{ N})\mathbf{k}$;
 $\mathbf{D} = (52 \text{ N})\mathbf{j} + (160 \text{ N})\mathbf{k}$.
- 4.66. (a) 750 N; (b) $\mathbf{C} = (250 \text{ N})\mathbf{i} + (750 \text{ N})\mathbf{j}$;
 $\mathbf{D} = -(1,00 \text{ kN})\mathbf{i} - (0,300 \text{ kN})\mathbf{j}$.
- 4.68. $T_A = 24,5 \text{ N}$; $T_B = 73,6 \text{ N}$; $T_C = 98,1 \text{ N}$.
- 4.70. 450 N em $x = 0,267 \text{ m}$, $z = 0,732 \text{ m}$.
- 4.72. (a) $T_{BD} = T_{BE} = 16,6 \text{ kN}$.
(b) $\mathbf{A} = (17,0 \text{ kN})\mathbf{i} + (45,1 \text{ kN})\mathbf{j}$.
- 4.74. (a) $T_{BD} = 3,50 \text{ kN}$; $T_{BC} = 4,88 \text{ kN}$.
(b) $\mathbf{A} = (7,50 \text{ kN})\mathbf{i} + (2,13 \text{ kN})\mathbf{j}$.
- 4.76. (a) $T_{DE} = T_{DF} = 1,12 \text{ kN}$.
(b) $\mathbf{A} = -(2,95 \text{ kN})\mathbf{i} + (5,77 \text{ kN})\mathbf{j}$.
- 4.78. (a) 786 N.
(b) $\mathbf{A} = -(491 \text{ N})\mathbf{i} - (324 \text{ N})\mathbf{k}$; $\mathbf{B} = (225 \text{ N})\mathbf{j}$.
- 4.80. (a) 15,0 N.
(b) $\mathbf{A} = -(14,7 \text{ N})\mathbf{i} + (34,5 \text{ N})\mathbf{j}$; $\mathbf{B} = (37,5 \text{ N})\mathbf{j}$.
- 4.82. (a) 689 N. (b) $\mathbf{A} = (503 \text{ N})\mathbf{i} + (424 \text{ N})\mathbf{j}$;
 $\mathbf{B} = (151 \text{ N})\mathbf{i} + (557 \text{ N})\mathbf{j} - (229 \text{ N})\mathbf{k}$.
- 4.84. (a) 1,55 kN. (b) $\mathbf{A} = (0,50 \text{ kN})\mathbf{i} + (1,09 \text{ kN})\mathbf{j}$;
 $\mathbf{B} = (0,151 \text{ kN})\mathbf{i} - (0,113 \text{ kN})\mathbf{j} - (1,00 \text{ kN})\mathbf{k}$.
- 4.86. (a) 15,0 N. (b) $\mathbf{B} = -(14,7 \text{ N})\mathbf{i} + (72,0 \text{ N})\mathbf{j}$;
 $\mathbf{M}_B = -(31,1 \text{ N} \cdot \text{m})\mathbf{i} - (13,2 \text{ N} \cdot \text{m})\mathbf{j}$.

- 4.88. (a) 689 N.
(b) $\mathbf{B} = (654 \text{ N})\mathbf{i} + (981 \text{ N})\mathbf{j} - (229 \text{ N})\mathbf{k}$;
 $\mathbf{M}_B = -(883 \text{ N} \cdot \text{m})\mathbf{i} + (1046 \text{ N} \cdot \text{m})\mathbf{j}$.
- 4.90. (a) 62,5 N.
(b) $\mathbf{A} = (30,0 \text{ N})\mathbf{j} + (22,5 \text{ N})\mathbf{k}$; $\mathbf{B} = (50,0 \text{ N})\mathbf{i}$.
- 4.92. (a) $D = 225 \text{ N}$. (b) $S = 300 \text{ N}$; $d = 0,75 \text{ m}$.
- 4.94. $\mathbf{B} = (153 \text{ N})\mathbf{i} - (225 \text{ N})\mathbf{k}$.
 $\mathbf{C} = +(2,50 \text{ N})\mathbf{j} + (225 \text{ N})\mathbf{k}$.
 $\mathbf{D} = -(153 \text{ N})\mathbf{i} + (30,0 \text{ N})\mathbf{j}$.
- 4.96. $T_{BD} = 2,90 \text{ kN}$; $T_{BE} = 5,25 \text{ kN}$; $T_{CD} = 2,00 \text{ kN}$.
- 4.98. (90 N) \mathbf{j} .
- 4.100. (45 N) \mathbf{k} .
- 4.102. 652 N.
- 4.104. (a) 450 N. (b) $\mathbf{A} = 3,00 \text{ kN} \leftarrow$; $\mathbf{B} = 3,00 \text{ kN} \rightarrow$.
- 4.106. 312 N.
- 4.108. $\mathbf{B} = 571 \text{ N} \searrow 57,7^\circ$; $\mathbf{C} = 356 \text{ N} \searrow 31,0^\circ$.
- 4.110. $\mathbf{A} = (375 \text{ N})\mathbf{j} - (500 \text{ N})\mathbf{k}$;
 $\mathbf{B} = (625 \text{ N})\mathbf{i} + (500 \text{ N})\mathbf{k}$;
 $\mathbf{C} = -(625 \text{ N})\mathbf{i} + (375 \text{ N})\mathbf{j}$.
- 4.112. $19,4^\circ$.
- 4.114. $\mathbf{A} = 58,5 \text{ kN} \searrow 60^\circ$; $\mathbf{B} = 39,6 \text{ kN} \searrow 83,8^\circ$.

CAPÍTULO 5

- 5.2. $\bar{X} = 82 \text{ mm}$, $\bar{Y} = 70 \text{ mm}$.
- 5.4. $\bar{X} = 70,0 \text{ mm}$, $\bar{Y} = 60,0 \text{ mm}$.
- 5.6. $\bar{X} = 16 \text{ mm}$, $\bar{Y} = 32 \text{ mm}$.
- 5.8. $\bar{X} = \bar{Y} = 127 \text{ mm}$.
- 5.10. $\bar{X} = \bar{Y} = 13 \text{ mm}$.
- 5.12. $\bar{X} = \bar{Y} = 225 \text{ mm}$.

5.14. $\bar{X} = 321 \text{ mm}$, $\bar{Y} = 53 \text{ mm}$.

5.16. $\bar{X} = \frac{1}{3}a(h_1 + 2h_2)/(h_1 + h_2)$.

5.18. 0,520.

5.20. 0,494.

5.22. $42 \times 10^3 \text{ mm}^3 \mathbf{e} - 42 \times 10^3 \text{ mm}^3$.

5.24. (a) $Q_x = \frac{1}{2}b(c^2 - y^2)$.
(b) $y = 0$; $(Q_x)_{\text{max}} = \frac{1}{2}bc^2$.

5.26. $\bar{X} = 84 \text{ mm}$, $\bar{Y} = 73 \text{ mm}$.

5.28. $\bar{X} = 18 \text{ mm}$, $\bar{Y} = 30 \text{ mm}$.

5.30. 120 mm.

5.32. (a) $\sqrt{3}r$. (b) $\sqrt{5}r$.

5.36. 15 mm.

5.38. $x = 0,7424a$; $-1,01\%$.

5.40. $x = 2a/5$, $y = 3b/7$.

5.42. $x = 3a/5$, $y = 12b/35$.

5.50. $y = 0,48h$.

5.52. $x = L/\pi$, $y = \pi a/8$.

5.54. $x = h$, $y = \frac{1}{4}h$.

5.56. (a) $9,13 \times 10^6 \text{ mm}^3$ (b) $10,6 \times 10^6 \text{ mm}^3$.

5.58. $A = 4\pi^2 rR$; $V = 2\pi^2 r^2 R$.

5.60. $7,72 \times 10^6 \text{ mm}^3$; 57,2 N.

5.62. $6,03 \text{ m}^2$.

5.64. $21,3 \times 10^3 \text{ mm}^3$; 154 g.

5.66. $90,8 \text{ cm}^2$.

5.68. (a) $4,27 \text{ m}^3$ (b) $13,1 \text{ m}^2$.

5.70. (a) $\pi R^2 h$. (b) $\frac{2}{3} \pi R^2 h$. (c) $\frac{1}{2} \pi R^2 h$. (d) $\frac{1}{3} \pi R^2 h$. (e) $\frac{1}{6} \pi R^2 h$.

5.72. $\mathbf{R} = 4,20 \text{ kN} \downarrow$, 1,143 m à direita de A; $\mathbf{A} = 2,20 \text{ kN} \uparrow$, $\mathbf{B} = 2,00 \text{ kN} \uparrow$.

5.74. $\mathbf{A} = 3,15 \text{ kN}$; $\mathbf{M}_A = 585 \text{ N} \cdot \text{m}$.

5.76. $\mathbf{A} = 2,04 \text{ kN} \uparrow$, $\mathbf{B} = 8,16 \text{ kN} \uparrow$.

5.78. $\mathbf{A} = 6,86 \text{ kN} \uparrow$, $\mathbf{B} = 1,76 \text{ kN} \uparrow$.

5.80. $\mathbf{B} = 18,9 \text{ kN} \uparrow$, $\mathbf{C} = 2,15 \text{ kN} \uparrow$.

- 5.82. $w_A = 10 \text{ kN/m}$; $w_B = 50 \text{ kN/m}$.
- 5.84. (a) $\mathbf{H} = 99,3 \text{ kN} \rightarrow$, $\mathbf{V} = 324 \text{ kN} \uparrow$; 2,03 m à direita de A.
(b) $\mathbf{R} = 105 \text{ kN} \nearrow 18,4^\circ$.
- 5.86. (a) 36,4 kN; 0,864 m abaixo de A. (b) 21,0 kN \leftarrow .
- 5.88. 0,30 m.
- 5.90. $\mathbf{A} = 130 \text{ kN} \nearrow 64,2^\circ$; $\mathbf{B} = 128 \text{ kN} \uparrow$.
- 5.92. 1,38 kN \swarrow .
- 5.94. 491 N.
- 5.96. 1,46 m.
- 5.98. $\mathbf{A} = 153 \text{ N} \uparrow$; $\mathbf{B}_x = 177 \text{ N} \leftarrow$; $\mathbf{B}_y = 789 \text{ N} \uparrow$.
- 5.100. $\frac{1}{8} b$ à direita da base do cone.
- 5.102. 27,8 mm acima da base.
- 5.104. $\bar{X} = \bar{Z} = 0$, $\bar{Y} = -0,608 h$.
- 5.106. $\bar{Y} = 19 \text{ mm}$.
- 5.108. $\bar{Z} = 86,8 \text{ mm}$.
- 5.110. $\bar{Z} = 51 \text{ mm}$.
- 5.112. $\bar{X} = 125 \text{ mm}$, $\bar{Y} = 167 \text{ mm}$, $\bar{Z} = 33 \text{ mm}$.
- 5.114. $\bar{X} = \bar{Z} = 90 \text{ mm}$, $\bar{Y} = 121 \text{ mm}$.
- 5.116. $\bar{X} = 0$, $\bar{Y} = 126 \text{ mm}$, $\bar{Z} = 64 \text{ mm}$.
- 5.118. 33 mm acima da base.
- 5.124. $\bar{x} = 5h/8$.
- 5.126. $\bar{x} = \frac{1}{2} a (1 - 4/\pi^2)$.
- 5.128. $\bar{x} = 3a/8$, $\bar{y} = h/4$, $\bar{z} = 3b/8$.
- 5.130. 42 mm.
- 5.132. $\bar{x} = 0$, $\bar{y} = 5h/16$, $\bar{z} = -a/4$.
- 5.134. $\bar{x} = 58 \text{ mm}$, $\bar{Y} = 83 \text{ mm}$.
- 5.136. (a) $\bar{X} = 300 \text{ mm}$, $\bar{Y} = -117 \text{ mm}$, $\bar{Z} = 0$. (b) 1,81.
- 5.138. $\bar{x} = 90 \text{ mm}$, $\bar{y} = 15 \text{ mm}$, $\bar{z} = 60 \text{ mm}$.
- 5.140. $\bar{a} + 155 \text{ m}^3$. (b) $+83 \text{ m}^3$.
- 5.142. $\bar{X} = 63,3 \text{ mm}$, $\bar{Y} = 15,4 \text{ mm}$, $\bar{Z} = 50,0 \text{ mm}$.
- 5.144. $\cos \alpha = \frac{1}{2} \operatorname{cosec} \theta$.

CAPÍTULO 6

- 6.2. $F_{AB} = 148 \text{ kN T}$; $F_{AC} = 72 \text{ kN C}$; $F_{AD} = 74 \text{ kN T}$; $F_{BC} = F_{CD} = 70 \text{ kN C}$.
- 6.4. $F_{AB} = 4,50 \text{ kN T}$; $F_{AC} = 3,90 \text{ kN C}$; $F_{BC} = 3,60 \text{ kN T}$.
- 6.6. $F_{AB} = 4 \text{ kN T}$; $F_{AD} = 15 \text{ kN T}$; $F_{BD} = 9 \text{ kN C}$; $F_{BE} = 5 \text{ kN T}$;
 $F_{CD} = 16 \text{ kN C}$; $F_{DE} = 4 \text{ kN C}$.
- 6.8. $F_{AB} = 3,75 \text{ kN T}$; $F_{AC} = 3,75 \text{ kN T}$; $F_{AD} = 6,00 \text{ kN C}$; $F_{BD} = 1,05 \text{ kN T}$;
 $F_{CD} = 3,60 \text{ kN T}$.
- 6.10. $F_{AB} = 2,10 \text{ kN C}$; $F_{AC} = F_{CE} = 2,00 \text{ kN T}$; $F_{AD} = 1,30 \text{ kN C}$;
 $F_{BC} = F_{CD} = 625 \text{ N T}$;
 $F_{BE} = 4,16 \text{ kN C}$.
- 6.12. $F_{AB} = 10 \text{ kN C}$; $F_{AC} = F_{BC} = F_{CD} = F_{CE} = 12 \text{ kN T}$; $F_{AD} = F_{BE} = 5,8 \text{ kN C}$.
- 6.14. BD, DG, FG, GH, HI, IJ .
- 6.16. AC, CE, EF, FG, GH .
- 6.18. (a) $\mathbf{A} = -(563 \text{ N})\mathbf{i} - (300 \text{ N})\mathbf{k}$; $\mathbf{B} = (300 \text{ N})\mathbf{k}$; $\mathbf{C} = (563 \text{ N})\mathbf{i} + (350 \text{ N})\mathbf{j}$.
(b) $F_{AB} = F_{AD} = F_{BC} = 0$; $F_{AC} = 850 \text{ N C}$; $F_{AE} = 1,06 \text{ kN T}$; $F_{BD} = 638 \text{ N T}$;
 $F_{BE} = F_{CD} = 563 \text{ N C}$; $F_{DE} = 300 \text{ N C}$.
- 6.20. (a) $\mathbf{B} = -(2,70 \text{ kN})\mathbf{k}$; $\mathbf{C} = -(1,80 \text{ kN})\mathbf{i} - (3,37 \text{ kN})\mathbf{j}$; $\mathbf{D} = (1,80 \text{ kN})\mathbf{i} + (3,37 \text{ kN})\mathbf{j}$.
(b) $F_{AB} = F_{CD} = 0$; $F_{AC} = 4,27 \text{ kN T}$; $F_{AD} = 4,27 \text{ kN C}$; $F_{BC} = 4,27 \text{ kN C}$;
 $F_{BD} = 4,27 \text{ kN T}$.
- 6.22. $F_{FG} = 5 \text{ kN T}$; $F_{FH} = 20 \text{ kN T}$.
- 6.24. $F_{CE} = 36 \text{ kN T}$; $F_{EF} = 15 \text{ kN C}$.
- 6.26. $F_{FG} = 22,7 \text{ kN T}$; $F_{FH} = 53,4 \text{ kN T}$.
- 6.28. $F_{EI} = 54 \text{ kN T}$; $F_{EG} = 60 \text{ kN C}$.
- 6.30. $F_{DG} = 510 \text{ kN C}$; $F_{EG} = 240 \text{ kN C}$.
- 6.32. $F_{BD} = 20 \text{ kN C}$; $F_{BE} = 25 \text{ kN C}$; $F_{CE} = 0$.
- 6.34. $F_{GJ} = 30 \text{ kN C}$; $F_{GK} = 50 \text{ kN C}$; $F_{IK} = 15 \text{ kN T}$.
- 6.36. $F_{DG} = 75 \text{ kN C}$; $F_{FG} = 59 \text{ kN T}$; $F_{FH} = 76 \text{ kN T}$.
- 6.38. $F_{AC} = 11 \text{ kN T}$; $F_{BE} = 11 \text{ kN C}$.
- 6.40. $F_{AE} = 142 \text{ kN C}$; $F_{DE} = 170 \text{ kN T}$.
- 6.42. $F_{DE} = 0$; $F_{BE} = 50 \text{ kN T}$; $F_{EF} = 25 \text{ kN T}$.
- 6.44. $F_{DE} = 7,5 \text{ kN C}$; $F_{BE} = 12,5 \text{ kN T}$; $F_{DG} = 12,5 \text{ kN T}$.
- 6.46. (a) Completamente vinculado; determinado.
(b) Completamente vinculado; indeterminado.
(c) Ineficazmente vinculado.

- 6.48. (a) Completamente vinculado; determinado.
 (b) Ineficazmente vinculado.
 (c) Completamente vinculado; indeterminado.
- 6.50. $F_{BD} = 300 \text{ N C}$; $C_x = 164 \text{ N } \leftarrow$, $C_y = 288 \text{ N } \uparrow$.
- 6.52. $A_x = 4\,500 \text{ N } \leftarrow$, $A_y = 375 \text{ N } \uparrow$; $B = 4\,125 \text{ N } \downarrow$; $D_x = 4\,500 \text{ N } \rightarrow$, $D_y = 3\,750 \text{ N } \uparrow$.
- 6.54. $A = 150 \text{ N } \rightarrow$; $B = 0$; $C_x = 150 \text{ N } \leftarrow$, $C_y = 100 \text{ N } \uparrow$; $D = 100 \text{ N } \downarrow$.
- 6.56. (a) $4,46 \text{ kN } \searrow 8,4^\circ$. (b) $3,53 \text{ kN } \searrow 51,3^\circ$.
- 6.58. $B = 410 \text{ N } \downarrow$; $C_x = 375 \text{ N } \leftarrow$; $C_y = 575 \text{ N } \uparrow$; $D_x = 375 \text{ N } \rightarrow$, $D_y = 60 \text{ N } \uparrow$.
- 6.60. (a) $1\,524 \text{ kN T}$. (b) $1\,133 \text{ kN C}$. (c) $1\,593 \text{ kN } \nearrow 62,1^\circ$.
- 6.62. (a) $A = 325 \text{ N } \nearrow 22,6^\circ$; $C = 600 \text{ N } \rightarrow$; $G = 300 \text{ N } \leftarrow$; $I = 125 \text{ N } \uparrow$.
 (b) $A = 325 \text{ N } \nearrow 22,6^\circ$; $C = 500 \text{ N } \rightarrow$; $G = 400 \text{ N } \leftarrow$; $I = 125 \text{ N } \uparrow$.
- 6.64. (a) $D_x = 750 \text{ N } \leftarrow$, $D_y = 250 \text{ N } \downarrow$; $E_x = 750 \text{ N } \leftarrow$, $E_y = 250 \text{ N } \uparrow$.
 (b) $D_x = 375 \text{ N } \rightarrow$, $D_y = 250 \text{ N } \downarrow$; $E_x = 375 \text{ N } \leftarrow$, $E_y = 250 \text{ N } \uparrow$.
- 6.66. (a) A' e B' . (b) 268 N T .
- 6.68. (a) 885 N T . (b) $C = 1\,310 \text{ N } \nearrow 85,0^\circ$.
- 6.70. $D_x = 13,60 \text{ kN } \rightarrow$, $D_y = 7,50 \text{ kN } \uparrow$; $E_x = 13,60 \text{ kN } \leftarrow$, $E_y = 2,70 \text{ kN } \downarrow$.
- 6.72. (a) $E_x = 15 \text{ kN } \leftarrow$, $E_y = 7,5 \text{ kN } \uparrow$. (b) $C_x = 15 \text{ kN } \leftarrow$, $C_y = 32,5 \text{ kN } \uparrow$.
- 6.74. (a) Em cada roda: $A = 12,5 \text{ kN } \uparrow$; $B = 188 \text{ kN } \uparrow$. (b) $C = 30 \text{ kN } \leftarrow$;
 $D_x = 30 \text{ kN } \rightarrow$, $D_y = 75 \text{ kN } \downarrow$.
- 6.76. (a) $2\,125 \text{ N}$. (b) Em cada roda: $A = 4\,740 \text{ N } \uparrow$; $B = 2\,730 \text{ N } \uparrow$; $C = 3\,570 \text{ N } \uparrow$.
- 6.78. $A_x = 5\,550 \text{ N } \leftarrow$, $A_y = 3\,000 \text{ N } \uparrow$;
 $B_x = 5\,550 \text{ N } \leftarrow$, $B_y = 4\,000 \text{ N } \downarrow$; $D_x = 11,1 \text{ kN } \rightarrow$, $D_y = 1\,000 \text{ N } \uparrow$.
- 6.80. $A_x = 4 \text{ kN } \leftarrow$, $A_y = 2 \text{ kN } \uparrow$;
 $B_x = 6 \text{ kN } \leftarrow$, $B_y = 1 \text{ kN } \uparrow$; $D_x = 10 \text{ kN } \rightarrow$, $D_y = 3 \text{ kN } \downarrow$.
- 6.82. $F_{AF} = \frac{1}{2} P$ comp.; $F_{BG} = P / \sqrt{2}$ ten.; $F_{GD} + \sqrt{2} P$ ten.; $F_{EH} = \frac{1}{2} P$ comp.
- 6.84. $F_{CF} = 7,88 \text{ kN C}$; $F_{DG} = 5,25 \text{ kN T}$.
- 6.86. $F_{BG} = 5,25 \text{ kN T}$; $F_{CH} = 2,63 \text{ kN C}$.
- 6.88. $A = 200 \text{ N } \uparrow$; $C_x = 1\,800 \text{ N } \rightarrow$, $C_y = 200 \text{ N } \downarrow$; $D = 1\,800 \text{ N } \leftarrow$.
- 6.90. (a) $C_x = 450 \text{ kN } \leftarrow$, $C_y = 420 \text{ kN } \uparrow$. (b) $B_x = 450 \text{ kN } \leftarrow$, $B_y = 30 \text{ kN } \downarrow$.
- 6.92. $A = P/15 \uparrow$; $D = 2P/15 \uparrow$; $E = 8P/15 \uparrow$; $H = 4P/15 \uparrow$.
- 6.94. (a) Rígido; $A = 2,24 P \searrow 26,6^\circ$; $B = 2 P \rightarrow$. (b) e (c) Não rígido.
- 6.96. $a \geq 0,6 \text{ m}$.
- 6.98. (a) $480 \text{ N } \downarrow$. (b) $500 \text{ N } \nearrow 73,7^\circ$.
- 6.100. (a) $2\,020 \text{ N } \downarrow$ (b) $1\,875 \text{ N } \nearrow 66,2^\circ$.
- 6.102. $D = 9\,360 \text{ N } \leftarrow$; $F = 6\,670 \text{ N } \searrow 15,1^\circ$.

- 6.104. $C = 86,8 \text{ kN } \rightarrow$; $E = 50,9 \text{ kN } \nearrow 23,1^\circ$.
- 6.106. $A_x = 180 \text{ N } \leftarrow$, $A_y = 2,25 \text{ kN } \downarrow$; $B = 2,55 \text{ kN } \nearrow 61,9^\circ$; $C = 1,02 \text{ kN } \leftarrow$.
- 6.108. (a) $2,14 \text{ kN } \downarrow$. (b) $5,00 \text{ kN } \downarrow$.
- 6.110. (a) $M_C = 115 \text{ N} \cdot \text{m } \uparrow$. (b) $C_x = 150 \text{ N } \leftarrow$, $C_y = 200 \text{ N } \uparrow$.
- 6.112. (a) 3 kN . (b) $3,35 \text{ kN } \nearrow 26,6^\circ$.
- 6.114. 60 N .
- 6.116. 147 N .
- 6.118. 200 N .
- 6.120. $179 \text{ N } \downarrow$.
- 6.122. (a) Zero. (b) $C_x = 25 \text{ kN } \leftarrow$, $C_y = 6,0 \text{ kN T } \downarrow$.
- 6.124. $F_{AB} = 1,48 \text{ kN C}$; $F_{DE} = 31,3 \text{ kN T}$; $F_{FI} = 4,55 \text{ kN C}$;
- 6.126. (a) $(52,5 \text{ N} \cdot \text{m}) \mathbf{i}$. (b) $\mathbf{A} = 0$, $\mathbf{M}_A = -(36 \text{ N} \cdot \text{m}) \mathbf{i}$; $\mathbf{B} = 0$, $\mathbf{M}_B = -(54 \text{ N} \cdot \text{m}) \mathbf{i}$.
- 6.128. (a) $0,8$. (b) $2,6 M_A \uparrow$.
- 6.130. (a) $M_G = 26,6 \text{ N} \cdot \text{m}$. (b) $\mathbf{B} = +(114 \text{ N}) \mathbf{i}$; $\mathbf{C} = -(114 \text{ N}) \mathbf{i}$; $\mathbf{E} = 0$.
- 6.132. $3,31 \text{ kN C}$.
- 6.134. (a) $126 \text{ N} \cdot \text{m } \uparrow$. (b) $117 \text{ N} \cdot \text{m } \uparrow$.
- 6.136. (a) $\mathbf{A} = 9,0 \text{ kN } \uparrow$, $\mathbf{M}_A = 21,6 \text{ kN} \cdot \text{m } \uparrow$. $\mathbf{D} = 6,0 \text{ kN } \uparrow$.
 (b) $\mathbf{A} = 0$, $\mathbf{M}_A = 27 \text{ kN} \cdot \text{m } \uparrow$; $\mathbf{D} = 15 \text{ kN } \uparrow$.
- 6.138. (a) $1,30 \text{ kN}$. (b) $13,5 \text{ N} \cdot \text{m}$.
- 6.140. $A_x = 90 \text{ N } \leftarrow$, $A_y = 60 \text{ N } \downarrow$; $B_x = 90 \text{ N } \rightarrow$, $B_y = 540 \text{ N } \uparrow$.
- 6.142. $F_{CE} = 30 \text{ kN T}$; $F_{DE} = 100 \text{ kN T}$; $F_{DF} = 90 \text{ kN C}$.
- 6.144. $A = 666 \text{ N } \searrow 63,2^\circ$; $F = 325 \text{ N } \nearrow 22,6^\circ$.

CAPÍTULO 7

- 7.2. (Em J_D) $\mathbf{F} = 0$; $\mathbf{V} = 200 \text{ N } \uparrow$, $\mathbf{M} = 30 \text{ N} \cdot \text{m } \uparrow$.
- 7.4. (Em J_D) $\mathbf{F} = 0$; $\mathbf{V} = 100 \text{ N } \uparrow$; $\mathbf{M} = 15 \text{ N} \cdot \text{m } \uparrow$.
- 7.6. (Em K_{CD}) $\mathbf{F} = 750 \text{ N } \downarrow$; $\mathbf{M} = 170 \text{ N} \cdot \text{m } \uparrow$. $\mathbf{V} = 400 \text{ N } \rightarrow$;
- 7.8. (Em CD) $\mathbf{F} = 270 \text{ N } \rightarrow$; $\mathbf{V} = 90 \text{ N } \uparrow$; $\mathbf{M} = 43,2 \text{ N} \cdot \text{m } \uparrow$.
- 7.10. (Em J_{CD}) $\mathbf{F} = 3,75 \text{ kN } \leftarrow$, $\mathbf{V} = 0$; $\mathbf{M} = 750 \text{ N} \cdot \text{m } \uparrow$.
- 7.12. (a) (Em AC) $\mathbf{F} = 520 \text{ N } \leftarrow$; $\mathbf{V} = 540 \text{ N } \uparrow$; $\mathbf{M} = 0$. (b) (Em AJ) $\mathbf{F} = 520 \text{ N } \leftarrow$;
 $\mathbf{V} = 540 \text{ N } \uparrow$; $\mathbf{M} = 54 \text{ N} \cdot \text{m } \uparrow$.
- 7.14. (Em J) $\mathbf{F} = 5,20 \text{ kN } \searrow 21,8^\circ$; $\mathbf{V} = 464 \text{ N } \nearrow 68,2^\circ$; $\mathbf{M} = 250 \text{ N} \cdot \text{m } \uparrow$.