RESPOSTAS

Capítulo 1

1.1. **a)** 4,66 m, **b)** 55,6 s, **c)** 4,56 kN, **d)** 2,77 Mg

1.2. 4,70 slug/pé^3 = 2,42 Mg/m^3

1.3. **a)** 0,000431 kg = 0,431 g,
b) 35,3(10^3) N = 35,3 kN,
c) 0,00532 km = 5,32 m

1.5. 55 mi/h = 88,5 km/h, 88,5 km/h = 24,6 m/s

1.6. **a)** (430 kg)^2 = 0,185 t^2,
b) (0,002 mg)^2 = 4 μg^2,
c) (230 m)^3 = 0,0122 km^3

1.7. **a)** 250(10^3) slugs = 3,65 Gg,
b) $W_T = mg$ = 35,8 MN,
c) $W_L = mg_L$ = 5,89 MN,
d) $m_L = m_T$ = 3,65 Gg

1.9. 1 Pa = 20,9(10^{-3}) lb/pé^2, 1 ATM = 101 kPa

1.10. **a)** W = 98,1 N,
b) W = 4,90 mN,
c) W = 44,1 kN

1.11. **a)** (354 mg)(45 km)/0,0356 kN = 0,447 kg · m/N,
b) (0,00453 t)(201 ms) = 0,911 kg · s,
c) 435 MN/23,2 mm = 18,8 GN/m

1.13. **a)** 20 lb · pés = 27,1 N · m,
b) 450 lb/pé^3 = 70,7 kN/m^3,
c) 15 pés/h = 1,27 mm/s

1.14. 40 slugs = 584 kg

1.15. ρ_a = 1,00 t/m^3

1.17. **a)** m = 2,04 g,
b) m = 15,3 t,
c) m = 6,12 Gg

1.18. **a)** m = 4,81 slug, **b)** m = 70,2 kg, **c)** W = 689 N,
d) W = 25,5 lb, **e)** m = 70,2 kg

1.19. F = 7,41(10^{-6}) N = 7,41 μN

Capítulo 2

2.1. F_R = 867 N, ϕ = 108°

2.2. **a)** F_R = 111 N, **b)** F_R' = 143 N

2.3. F_R = 393 lb, ϕ = 353°

2.5. F_{1u} = 205 N, F_{1v} = 160 N

2.6. F_{2u} = 376 N, F_{2v} = 482 N

2.7. F_R = 10,8 kN, ϕ = 3,16°

2.9. F_{AB} = 448 N, F_{AC} = 366 N

2.10. F_{AB} = 314 lb, F_{AC} = 256 lb

2.11. F_a = 30,6 lb, F_b = 26,9 lb

2.13. F_{AB} = 485 lb, θ = 24,6°

2.14. T = 744 lb, θ = 23,8°

2.15. θ = 53,5°, F_{AB} = 621 lb

2.17. **a)** F_y = 16,3 lb, F_n = −22,3 lb,
b) F_t = 5,98 lb, F_s = 16,3 lb

2.18. θ = 18,6°, F = 319 N

2.19. $\phi = \theta$ = 70,5°

2.21. F_B = 325 N, F_A = 893 N, θ = 70,0°

2.22. F_R = 19,2 N, θ = 2,37° ↖

2.23. F_R = 19,2 N, θ = 2,37° ↖

2.25. F_A = 3,66 kN, F_B = 7,07 kN

2.26. F_B = 5,00 kN, F_A = 8,66 kN, θ = 60,0°

2.27. F_A = 439 N, F_B = 311 N

2.29. θ = 10,9°, F_{min} = 235 lb

2.30. F = 97,4 lb, θ = 16,2°

2.31. F_x = 514 lb, F_y = −613 lb

2.33. F = 11,3 kN

2.34. F_R = 546 N, θ = 253°

2.35. θ = 37,0°, F_1 = 889 N

2.37. θ = 29,1°, F_1 = 275 N

2.38. F_R = 1,03 kN, θ = 87,9°

2.39. $\mathbf{F}_1 = \{-15{,}0\mathbf{i} - 26{,}0\mathbf{j}\}$ kN,
$\mathbf{F}_2 = \{-10{,}0\mathbf{i} + 24{,}0\mathbf{j}\}$ kN

2.41. F_R = 867 N, θ = 108°

2.42. F_R = 19,2 N, θ = 2,37° ↖

2.43. θ = 68,6°, F_B = 960 N

2.45. F_{1x} = 141 N, F_{1y} = 141 N, F_{2x} = −130 N,
F_{2y} = 75 N

2.46. F_R = 217 N, θ = 87,0°

2.47. F_{1x} = −200 lb, F_{1y} = 0, F_{2x} = 320 lb,
F_{2y} = −240 lb, F_{3x} = 180 lb, F_{3y} = 240 lb,
F_{4x} = −300 lb, F_{4y} = 0

2.49. θ = 54,3°, F_A = 686 N

2.50. F_R = 1,23 kN, θ = 6,08°

2.51. $\mathbf{F}_1 = \{90\mathbf{i} - 120\mathbf{j}\}$ lb,
$\mathbf{F}_2 = \{-275\mathbf{j}\}$ lb, $\mathbf{F}_3 = \{-37{,}5\mathbf{i} - 65{,}0\mathbf{j}\}$ lb,
F_R = 463 lb

2.53. F = 5,96 kN, F_R = 2,33 kN

2.54. $\mathbf{F}_1 = \{F_1 \cos\theta\mathbf{i} + F_1 \operatorname{sen}\theta\mathbf{j}\}$ N,

$\mathbf{F}_2 = \{350\mathbf{i}\}$ N, $\mathbf{F}_3 = \{-100\mathbf{j}\}$ N,
$\theta = 67{,}0°$, $F_1 = 434$ N

2.55. $\theta = 117°$, $F_3 = 1{,}12\,F_1$

2.57. $F_R = 161$ lb, $\theta = 38{,}3°$

2.58. $F = 2{,}03$ kN, $F_R = 7{,}87$ kN,

2.59. $F_1 = 87{,}7$ N, $\alpha_1 = 46{,}9°$, $\beta_1 = 125°$, $\gamma_1 = 62{,}9°$,
$F_2 = 98{,}6$ N, $\alpha_2 = 114°$, $\beta_2 = 150°$, $\gamma_2 = 72{,}3°$

2.61. $F = 50$ N, $\alpha = 74{,}1°$, $\beta = 41{,}3°$, $\gamma = 53{,}1°$

2.62. $F_R = 39{,}4$ lb, $\alpha = 52{,}8°$, $\beta = 141°$, $\gamma = 99{,}5°$

2.63. $\beta = 90°$, $\mathbf{F} = \{-30\mathbf{i} - 52{,}0\mathbf{k}\}$ N

2.65. $\mathbf{F}_1 = \{53{,}1\mathbf{i} - 44{,}5\mathbf{j} + 40\mathbf{k}\}$ lb, $\alpha_1 = 48{,}4°$,
$\beta_1 = 124°$, $\gamma_1 = 60°$, $\mathbf{F}_2 = \{-130\mathbf{k}\}$ lb,
$\alpha_2 = 90°$, $\beta_2 = 90°$, $\gamma_2 = 180°$

2.66. $\alpha_1 = 45{,}6°$, $\beta_1 = 53{,}1°$, $\gamma_1 = 66{,}4°$

2.67. $\alpha_1 = 90°$, $\beta_1 = 53{,}1°$, $\gamma_1 = 66{,}4°$

2.69. $\mathbf{F}_1 = \{176\mathbf{j} - 605\mathbf{k}\}$ lb,
$\mathbf{F}_2 = \{125\mathbf{i} - 177\mathbf{j} + 125\mathbf{k}\}$ lb,
$\mathbf{F}_R = \{125\mathbf{i} - 0{,}377\mathbf{j} - 480\mathbf{k}\}$ lb,
$F_R = 496$ lb; $\alpha = 75{,}4°$, $\beta = 90{,}0°$, $\gamma = 165°$

2.70. $F_R = 369$ N, $\alpha = 19{,}5°$, $\beta = 78{,}3°$, $\gamma = 105°$

2.71. $F_2 = 66{,}4$ lb, $\alpha = 59{,}8°$, $\beta = 107°$, $\gamma = 144°$

2.73. $\mathbf{F}_1 = \{86{,}5\mathbf{i} + 186\mathbf{j} - 143\mathbf{k}\}$ N,
$\mathbf{F}_2 = \{-200\mathbf{i} + 283\mathbf{j} + 200\mathbf{k}\}$ N,
$\mathbf{F}_R = \{-113\mathbf{i} + 468\mathbf{j} + 56{,}6\mathbf{k}\}$ N,
$F_R = 485$ N, $\alpha = 104°$, $\beta = 15{,}1°$, $\gamma = 83{,}3°$

2.74. $F_x = 1{,}28$ kN, $F_y = 2{,}60$ kN, $F_z = 0{,}776$ kN

2.75. $F = 2{,}02$ kN, $F_y = 0{,}523$ kN

2.77. $F_3 = 166$ N, $\alpha = 97{,}5°$, $\beta = 63{,}7°$, $\gamma = 27{,}5°$

2.78. $\alpha_{F_1} = 36{,}9°$, $\beta_{F_1} = 90{,}0°$, $\gamma_{F_1} = 53{,}1°$,
$\alpha_R = 69{,}3°$, $\beta_R = 52{,}2°$, $\gamma_R = 45{,}0°$

2.79. $F_x = 40$ N, $F_y = 40$ N, $F_z = 56{,}6$ N

2.81. $r = 31{,}5$m, $\alpha = 69{,}6°$, $\beta = 116°$, $\gamma = 34{,}4°$

2.82. $\mathbf{r}_{AB} = \{2\mathbf{i} - 7\mathbf{j} - 5\mathbf{k}\}$ pés, $r_{AB} = 8{,}83$ pés,
$\alpha = 76{,}9°$, $\beta = 142°$, $\gamma = 124°$

2.83. $\alpha = 73{,}4°$, $\beta = 64{,}6°$, $\gamma = 31{,}0°$

2.85. $\mathbf{r} = \{-2{,}35\mathbf{i} + 3{,}93\mathbf{j} + 3{,}71\mathbf{k}\}$ pés, $r = 5{,}89$ pés,
$\alpha = 113°$, $\beta = 48{,}2°$, $\gamma = 51{,}0°$

2.86. $\mathbf{F} = \{404\mathbf{i} + 276\mathbf{j} - 101\mathbf{k}\}$ lb,
$\alpha = 36{,}0°$, $\beta = 56{,}5°$, $\gamma = 102°$

2.87. $r_{AB} = 2{,}11$ m

2.89. $r_{AB} = 17{,}0$ pés, $\mathbf{F} = \{-160\mathbf{i} - 180\mathbf{j} + 240\mathbf{k}\}$ lb

2.90. $r_{AB} = 467$ mm

2.91. $r_{AD} = 1{,}50$ m, $r_{BD} = 1{,}50$ m, $r_{CD} = 1{,}73$ m

2.93. $\mathbf{F} = \{452\mathbf{i} + 370\mathbf{j} - 136\mathbf{k}\}$ lb, $\alpha = 41{,}1°$,
$\beta = 51{,}9°$, $\gamma = 103°$

2.94. $F_R = 316$ N, $\alpha = 60{,}1°$, $\beta = 74{,}6°$, $\gamma = 146°$

2.95. $\mathbf{F}_A = \{285\mathbf{j} - 93{,}0\mathbf{k}\}$ N,
$\mathbf{F}_C = \{159\mathbf{i} + 183\mathbf{j} - 59{,}7\mathbf{k}\}$ N

2.97. $\mathbf{F}_{AB} = \{75{,}5\mathbf{i} - 43{,}6\mathbf{j} - 122\mathbf{k}\}$ lb,
$\mathbf{F}_{BC} = \{26{,}8\mathbf{i} + 33{,}5\mathbf{j} - 90{,}4\mathbf{k}\}$ lb,
$F_R = 236$ lb, $\alpha = 64{,}3°$, $\beta = 92{,}5°$, $\gamma = 154°$

2.98. $\mathbf{F}_A = \{-43{,}5\mathbf{i} + 174\mathbf{j} - 174\mathbf{k}\}$ N,
$\mathbf{F}_B = \{53{,}2\mathbf{i} - 79{,}8\mathbf{j} - 146\mathbf{k}\}$ N

2.99. $\mathbf{F}_1 = \{-26{,}2\mathbf{i} - 41{,}9\mathbf{j} + 62{,}9\mathbf{k}\}$ lb,
$\mathbf{F}_2 = \{13{,}4\mathbf{i} - 26{,}7\mathbf{j} - 40{,}1\mathbf{k}\}$ lb,
$F_R = 73{,}5$ lb, $\alpha = 100°$, $\beta = 159°$, $\gamma = 71{,}9°$

2.101. $\mathbf{F} = \{13{,}4\mathbf{i} + 23{,}2\mathbf{j} + 53{,}7\mathbf{k}\}$ lb

2.102. $\mathbf{F} = \{-6{,}61\mathbf{i} - 3{,}73\mathbf{j} + 9{,}29\mathbf{k}\}$ lb

2.103. $x = 7{,}65$ pés, $y = 4{,}24$ pés, $z = 3{,}76$ pés

2.105. $\mathbf{F}_{EA} = \{12\mathbf{i} - 8\mathbf{j} - 24\mathbf{k}\}$ kN,
$\mathbf{F}_{EB} = \{12\mathbf{i} + 8\mathbf{j} - 24\mathbf{k}\}$ kN,
$\mathbf{F}_{EC} = \{-12\mathbf{i} + 8\mathbf{j} - 24\mathbf{k}\}$ kN,
$\mathbf{F}_{ED} = \{-12\mathbf{i} - 8\mathbf{j} - 24\mathbf{k}\}$ kN, $\mathbf{F}_R = \{-96\mathbf{k}\}$ kN

2.106. $F_R = 1{,}50$ kN, $\alpha = 77{,}6°$, $\beta = 90{,}6°$, $\gamma = 168°$

2.107. $\mathbf{F} = \{143\mathbf{i} + 248\mathbf{j} - 201\mathbf{k}\}$ lb

2.109. O componente de $(\mathbf{B} + \mathbf{D})$ na direção **A** é igual à soma dos componentes de **B** e **D** na direção **A**.

2.110. $\theta = 121°$

2.111. $\theta = 109°$

2.113. $\theta = 70{,}5°$

2.114. $F_1 = 19{,}4$ N, $F_2 = 53{,}4$ N

2.115. $\theta = 74{,}2°$

2.117. $F_{\parallel} = 99{,}1$ N, $F_{\perp} = 592$ N

2.118. $F_{\parallel} = 82{,}4$ N, $F_{\perp} = 594$ N

2.119. $F_1 = 333$ N, $F_2 = 373$ N

2.121. Proj. $F = 31{,}1$ N

2.122. $\theta = 70{,}5°$

2.123. $\phi = 65{,}8°$

2.125. $(F_1)_{F_2} = 5{,}44$ lb

2.126. $\theta = 100°$

2.127. $\theta = 34{,}2°$

2.129. $\theta = 82{,}0°$

2.130. $(\mathbf{F}_1)_{F_2} = 50{,}6$ N

2.131. $\theta = 97{,}3°$

2.133. $F_3 = 428$ lb, $\alpha = 88{,}3°$, $\beta = 20{,}6°$, $\gamma = 69{,}5°$

2.134. $F_3 = 250$ lb, $\alpha = 87{,}0°$, $\beta = 143°$, $\gamma = 53{,}1°$

2.135. $F_{BA} = 215$ lb, $\theta = 52{,}7°$

2.137. $\phi = \dfrac{\theta}{2}$, $F_R = 2F\cos\left(\dfrac{\theta}{2}\right)$

2.138. $\theta = 74{,}0°$, $\phi = 33{,}9°$

2.139. Proj $F_{AB} = 70{,}5$ N, Proj $F_{AC} = 65{,}1$ N

2.141. $\theta = 60°$, $P = 40$ lb, $T = 69{,}3$ lb

Capítulo 3

3.1. $F_1 = 435$ lb, $F_2 = 171$ lb

3.2. $\theta = 31{,}8°$, $F = 4{,}94$ kN

3.3. $\theta = 12{,}9°$, $F_1 = 552$ N

3.5. $F_1 = 1{,}83$ kN, $F_2 = 9{,}60$ kN

3.6. $\theta = 4{,}69°$, $F_1 = 4{,}31$ kN

3.7. $F_{BC} = 2{,}99$ kN, $F_{AB} = 3{,}78$ kN

3.9. $\theta = 34{,}2°$

3.10. $\theta = 11{,}5°$

3.11. $F = 1{,}13$ mN

3.13. $x_{AC} = 0{,}793$ m, $x_{AB} = 0{,}467$ m

3.14. $m = 12{,}8$ kg

3.15. $F = 158$ N
3.17. $W = 76{,}6$ lb
3.18. $\theta = 78{,}7°$, $F_{CD} = 127$ lb
3.19. $\theta = 78{,}7°$, $W = 51{,}0$ lb
3.21. $d = 2{,}42$ m
3.22. $\theta = 60°$, $T_{AB} = 34{,}6$ lb
3.23. $\theta = 60°$, $W = 46{,}2$ lb
3.25. $s = 5{,}33$ pés
3.26. $W = 6$ lb
3.27. $F_{AC} = F_{AB} = F = \{2{,}45 \operatorname{cosec} \theta\}$ kN, $l = 1{,}72$ m
3.29. $l = 19{,}1$ pol
3.30. Em C e D, $T = 106$ lb
3.31. $\theta = 35{,}0°$
3.33. $W_B = 18{,}3$ lb
3.34. $l = 2{,}65$ pés
3.35. $F_{BD} = 171$ N, $F_{BC} = 145$ N
3.37. $\theta = 43{,}0°$
3.38. $y = 6{,}59$ m
3.39. $m_B = 3{,}58$ kg, $N = 19{,}7$ N
3.41. $F_1 = 608$ N, $\alpha = 79{,}2°$, $\beta = 16{,}4°$, $\gamma = 77{,}8°$
3.42. $F_1 = 800$ N, $F_2 = 147$ N, $F_3 = 564$ N
3.43. $F_1 = 5{,}60$ kN, $F_2 = 8{,}55$ kN, $F_3 = 9{,}44$ kN
3.45. $F_{AD} = 1{,}20$ kN, $F_{AC} = 0{,}40$ kN, $F_{AB} = 0{,}80$ kN
3.46. $F_{AC} = 130$ N, $F_{AD} = 510$ N, $F = 1{,}06$ kN
3.47. $s_{OB} = 327$ mm, $s_{OA} = 218$ mm
3.49. $F_{AB} = 0{,}980$ kN, $F_{AC} = 0{,}463$ kN, $F_{AD} = 1{,}55$ kN
3.50. $F_{AO} = 319$ N, $F_{AB} = 110$ N, $F_{AC} = 85{,}8$ N
3.51. $W = 138$ N
3.53. $F_{AE} = F_{AD} = 1{,}42$ kN $F_{AB} = 1{,}32$ kN
3.54. $F_{AB} = F_{AC} = 16{,}6$ kN, $F_{AD} = 55{,}2$ kN
3.55. $F_B = 19{,}2$ kN, $F_C = 10{,}4$ kN, $F_D = 6{,}32$ kN
3.57. $F_{AB} = 520$ N, $F_{AC} = F_{AD} = 260$ N, $d = 3{,}61$ m
3.58. $F_{AB} = 35{,}9$ lb, $F_{AC} = F_{AD} = 25{,}4$ lb
3.59. $W = 267$ lb
3.61. $F_{AB} = 469$ lb, $F_{AC} = F_{AD} = 331$ lb
3.62. $x = 0{,}190$ m, $y = 0{,}0123$ m
3.63. $F_{AD} = 1{,}42$ kip, $F_{AC} = 0{,}914$ kip, $F_{AB} = 1{,}47$ kip
3.65. $F_{OB} = 120$ N, $F_{OC} = 150$ N, $F_{OD} = 480$ N
3.66. $F_A = 34{,}6$ lb, $F_B = 57{,}3$ lb
3.67. $F = 40{,}8$ lb
3.69. Romeu pode subir pela corda.
Romeu e Julieta podem descer pela corda.
3.70. $F_1 = 8{,}26$ kN, $F_2 = 3{,}84$ kN, $F_3 = 12{,}2$ kN
3.71. $\theta = 90°$, $F_{AC} = 160$ lb, $\theta = 120°$, $F_{AB} = 160$ lb
3.73. $W = 240$ lb
3.74. $F_{CD} = 625$ lb, $F_{CA} = F_{CB} = 198$ lb
3.75. $F_1 = 0$, $F_2 = 311$ lb, $F_3 = 238$ lb

Capítulo 4

4.3. Se $\mathbf{A} \cdot (\mathbf{B} \times \mathbf{C}) = 0$, então o volume é igual a zero, de modo que **A**, **B** e **C** são coplanares.

4.5. $M_P = 2{,}37$ kN · m ↰
4.6. $M_O = 2{,}88$ kN · m ↳
4.7. $M_P = 3{,}15$ kN · m ↳
4.9. $M_P = 3{,}15$ kN · m ↰
4.10. $(M_{F_1})_O = 24{,}1$ N · m ↳,
$(M_{F_2})_O = 14{,}5$ N · m ↳.
4.11. $M_O = 2{,}42$ kip · pés ↲
4.13. $(M_{F_1})_B = 4{,}125$ kip · pés ↳,
$(M_{F_2})_B = 2{,}00$ kip · pés ↳,
$(M_{F_3})_B = 40{,}0$ lb · pés ↳
4.14. $M_B = 90{,}6$ lb · pés ↰, $M_C = 141$ lb · pés ↰
4.15. $M_A = 195$ lb · pés ↰
4.17. $M_O = 28{,}1$ N · m ↲, $\theta = 88{,}6°$,
$(M_O)_{máx} = 32{,}0$ N · m ↲
4.18. **a)** $(M_A)_{máx} = 330$ lb · pés, $\theta = 76{,}0°$,
b) $(M_A)_{mín} = 0$, $\theta = 166°$
4.19. $-M_O = 120$ N · m ↳, $+M_O = 520$ N · m ↳
4.21. **a)** $M_A = 13{,}0$ N · m ↲, **b)** $F = 35{,}2$ N
4.22. $(M_{F_1})_A = 433$ N · m ↲,
$(M_{F_2})_A = 1{,}30$ kN · m ↲,
$(M_{F_3})_A = 800$ N · m ↲.
4.23. $\theta = 7{,}48°$
4.25. $F_A = 28{,}9$ lb
4.26. $(M_O)_{máx} = 80$ kN · m, $x = 24{,}0$ m
4.27. $(M_O)_{máx} = 80{,}0$ kN · m, $\theta = 33{,}6°$
4.29. $M_A = 1200 \operatorname{sen} \theta + 800 \cos \theta$ ↳
4.30. $M_A = 0{,}418$ N · m ↳,
$M_B = 4{,}92$ N · m ↲
4.31. $M_A = \{1{,}18 \cos \theta(7{,}5 + x)\}$ kN · m ↲,
$(M_A)_{máx} = 14{,}7$ kN · m ↲
4.33. $F = 1{,}33$ kip, $F' = 1{,}63$ kip
4.34. $\mathbf{M}_O = \{260\mathbf{i} + 180\mathbf{j} + 510\mathbf{k}\}$ N · m
4.35. $\mathbf{M}_O = \{440\mathbf{i} + 220\mathbf{j} + 990\mathbf{k}\}$ N · m
4.37. $\mathbf{M}_P = \{-116\mathbf{i} + 16\mathbf{j} - 135\mathbf{k}\}$ kN · m
4.38. $\mathbf{M}_O = \{-128\mathbf{i} + 128\mathbf{j} - 257\mathbf{k}\}$ N · m
4.39. $\mathbf{M}_B = \{-37{,}6\mathbf{i} + 90{,}7\mathbf{j} - 155\mathbf{k}\}$ N · m
4.41. $\mathbf{M}_C = \{-35{,}4\mathbf{i} - 128\mathbf{j} - 222\mathbf{k}\}$ lb · pés
4.42. $\mathbf{M}_A = \{-16{,}0\mathbf{i} - 32{,}1\mathbf{k}\}$ N · m
4.43. $F_{AB} = 18{,}6$ lb
4.45. $\mathbf{M}_B = \{10{,}6\mathbf{i} + 13{,}1\mathbf{j} + 29{,}2\mathbf{k}\}$ N · m
4.46. $\mathbf{M}_O = \{373\mathbf{i} - 99{,}9\mathbf{j} + 173\mathbf{k}\}$ N · m
4.47. $\mathbf{M}_R = \{-1{,}90\mathbf{i} + 6{,}00\mathbf{j}\}$ kN · m
4.49. $y = 1$ m, $z = 3$ m, $d = 1{,}15$ m
4.50. $M_A = \sqrt{12\,656{,}25 \operatorname{sen}^2 \theta + 22\,500}$,
$M_{máx}$ em $\theta = 90°$, $M_{mín}$ em $\theta = 0°, 180°$
4.51. $(\mathbf{M}_{Oa})_F = \{218\mathbf{j} + 163\mathbf{k}\}$ N · m
4.53. $(\mathbf{M}_R)_{Oa} = \{26{,}1\mathbf{i} - 15{,}1\mathbf{j}\}$ lb · pés
4.54. $(M_{AB})_1 = 72{,}0$ N · m, $(M_{AB})_2 = (M_{AB})_3 = 0$
4.55. $M_x = 44{,}4$ lb · pés
4.57. $M_y = 0{,}277$ N · m
4.58. $\mathbf{M}_y = \{-78{,}4\mathbf{j}\}$ lb · pés
4.59. $M_x = 15{,}0$ lb · pés, $M_y = 4{,}00$ lb · pés,
$M_z = 36{,}0$ lb · pés

4.61. $M_x = 3{,}75\ \text{N} \cdot \text{m}$
4.62. $M_z = 109\ \text{lb} \cdot \text{pol}$
4.63. $M_{CA} = 226\ \text{N} \cdot \text{m}$
4.65. $P = 8{,}50\ \text{lb}$
4.66. $M_y = 282\ \text{lb} \cdot \text{pés}$
4.67. $\mathbf{M}_z = \{35{,}4\mathbf{k}\}\ \text{N} \cdot \text{m}$
4.69. $M_C = 18{,}3\ \text{kN} \cdot \text{m}\ \curvearrowleft$
4.70. $M_C = 650\ \text{lb} \cdot \text{pés}\ \curvearrowleft$
4.71. $M_C = 17{,}6\ \text{kN} \cdot \text{m}\ \curvearrowleft$
4.73. $F = 133\ \text{N}$, $P = 800\ \text{N}$
4.74. $T = 0{,}909\ \text{kip}$
4.75. $N = 26{,}0\ \text{N}$
4.77. $M = 900\ \text{lb} \cdot \text{pés}$, $R_B = 500\ \text{lb}$
4.78. $F = 139\ \text{lb}$
O momento de binário resultante pode atuar em qualquer ponto.
4.79. $\mathbf{M}_C = \{-5\mathbf{i} + 8{,}75\mathbf{j}\}\ \text{N} \cdot \text{m}$
4.81. $d = 1{,}54\ \text{m}$
4.82. $F = 167\ \text{lb}$
O momento de binário resultante pode atuar em qualquer ponto.
4.83. $d = 2{,}03$ pés
4.85. $M_C = 126\ \text{lb} \cdot \text{pés}$
4.86. $\mathbf{M}_C = \{-360\mathbf{i} + 380\mathbf{j} + 320\mathbf{k}\}\ \text{lb} \cdot \text{pés}$
4.87. $\mathbf{M}_C = \{-411\mathbf{i} - 257\mathbf{j} - 651\mathbf{k}\}\ \text{lb} \cdot \text{pés}$
4.89. $(M_R)_x = 4{,}84\ \text{kip} \cdot \text{pés}$, $(M_R)_y = 29{,}8\ \text{kip} \cdot \text{pés}$
4.90. $\mathbf{M}_C = \{7{,}01\mathbf{i} + 42{,}1\mathbf{j}\}\ \text{N} \cdot \text{m}$
4.91. $F = 35{,}1\ \text{N}$
4.93. $\mathbf{M}_R = \{11{,}0\mathbf{i} - 49{,}0\mathbf{j} - 40{,}0\mathbf{k}\}\ \text{lb} \cdot \text{pés}$,
$M_R = 64{,}2\ \text{lb} \cdot \text{pés}$, $\alpha = 80{,}1°$, $\beta = 140°$, $\gamma = 129°$
4.94. $M_R = 59{,}9\ \text{N} \cdot \text{m}$, $\alpha = 99{,}0°$, $\beta = 106°$, $\gamma = 18{,}3°$
4.95. $M = 18{,}3\ \text{N} \cdot \text{m}$, $\alpha = 155°$, $\beta = 115°$, $\gamma = 90°$
4.97. $d = 342\ \text{mm}$
4.98. $F_O = 375\ \text{N}$, $M_O = 100\ \text{N} \cdot \text{m}\ \curvearrowright$
4.99. $F_P = 375\ \text{N}$, $M_P = 737\ \text{N} \cdot \text{m}\ \curvearrowleft$
4.101. $F_R = 178\ \text{N}$, $\theta = 73{,}0°\ \nearrow$, $M_{R_C} = 2{,}68\ \text{kN} \cdot \text{m}\ \curvearrowleft$
4.102. $F_R = 274\ \text{lb}$, $\theta = 5{,}24°\ \measuredangle$, $M_O = 4{,}61\ \text{kip} \cdot \text{pés}\ \curvearrowleft$
4.103. $F_R = 274\ \text{lb}$, $\theta = 5{,}24°\ \measuredangle$, $M_P = 5{,}48\ \text{kip} \cdot \text{pés}\ \curvearrowleft$
4.105. $F_R = 6{,}57\ \text{kN}$, $\theta = 57{,}4°\ \nwarrow$, $M_{R_P} = 31{,}0\ \text{kN} \cdot \text{m}\ \curvearrowleft$
4.106. $F_R = 2{,}10\ \text{kN}$, $\theta = 81{,}6°\ \measuredangle$, $M_O = 10{,}6\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.107. $F_R = 2{,}10\ \text{kN}$, $\theta = 81{,}6°\ \measuredangle$, $M_P = 16{,}8\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.109. $F_R = 375\ \text{lb}\ \uparrow$, $x = 2{,}47$ pés
4.110. $F_R = 5{,}93\ \text{kN}$, $\theta = 77{,}8°\ \nearrow$,
$M_{R_A} = 34{,}8\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.111. $F_R = 5{,}93\ \text{kN}$, $\theta = 77{,}8°\ \nearrow$, $M_{R_B} = 11{,}6\ \text{kN} \cdot \text{m}\ \curvearrowleft$
4.113. $F = 798\ \text{lb}$, $\theta = 67{,}9°\ \nearrow$, $x = 6{,}57$ pés
4.114. $F = 922\ \text{lb}$, $\theta = 77{,}5°\ \nearrow$, $x = 3{,}56$ pés
4.115. $F = 1302\ \text{N}$, $\theta = 84{,}5°\ \nearrow$ $x = 7{,}36\ \text{m}$
4.117. $F_2 = 25{,}9\ \text{lb}$, $\theta = 18{,}1°$, $F_1 = 68{,}1\ \text{lb}$
4.118. $F_R = 10{,}75\ \text{kip}\ \downarrow$, $M_{R_A} = 99{,}5\ \text{kip} \cdot \text{pés}\ \curvearrowleft$
4.119. $F_R = 10{,}75\ \text{kip}\ \downarrow$, $d = 9{,}26$ pés
4.121. $F_R = 991\ \text{N}$, $\theta = 63{,}0°\ \nearrow$, $x = 2{,}64\ \text{m}$
4.122. $F_R = 65{,}9\ \text{lb}$, $\theta = 49{,}8°\ \nwarrow$, $d = 2{,}10$ pés
4.123. $F_R = 65{,}9\ \text{lb}$, $\theta = 49{,}8°\ \nwarrow$, $d = 4{,}62$ pés
4.125. $\mathbf{F}_R = \{8\mathbf{i} + 6\mathbf{j} + 8\mathbf{k}\}\ \text{kN}$,
$\mathbf{M}_{RO} = \{-10\mathbf{i} + 18\mathbf{j} - 56\mathbf{k}\}\ \text{kN} \cdot \text{m}$
4.126. $\mathbf{F}_R = \{8\mathbf{i} + 6\mathbf{j} + 8\mathbf{k}\}\ \text{kN}$,
$\mathbf{M}_{RP} = \{-46\mathbf{i} + 66\mathbf{j} - 56\mathbf{k}\}\ \text{kN} \cdot \text{m}$
4.127. $\mathbf{F}_R = \{8\mathbf{i} + 6\mathbf{j} + 8\mathbf{k}\}\ \text{kN}$,
$\mathbf{M}_{RQ} = \{-10\mathbf{i} - 30\mathbf{j} - 20\mathbf{k}\}\ \text{kN} \cdot \text{m}$
4.129. $\mathbf{F}_R = \{-28{,}3\mathbf{j} - 68{,}3\mathbf{k}\}\ \text{N}$,
$\mathbf{M}_{RA} = \{-20{,}5\mathbf{j} + 8{,}49\mathbf{k}\}\ \text{N} \cdot \text{m}$
4.130. $\mathbf{F}_R = \{400\mathbf{i} + 300\mathbf{j} - 650\mathbf{k}\}\ \text{N}$,
$\mathbf{M}_{R_A} = \{-3100\mathbf{i} + 4800\mathbf{j}\}\ \text{N} \cdot \text{m}$
4.131. $\mathbf{F}_R = \{0{,}232\mathbf{i} + 5{,}06\mathbf{j} + 12{,}4\mathbf{k}\}\ \text{kN}$,
$\mathbf{M}_{R_O} = \{36{,}0\mathbf{i} - 26{,}1\mathbf{j} + 12{,}2\mathbf{k}\}\ \text{kN} \cdot \text{m}$
4.133. $F_R = 140\ \text{kN}\ \downarrow$, $y = 7{,}14\ \text{m}$, $x = 5{,}71\ \text{m}$
4.134. $F_R = 140\ \text{kN}\ \downarrow$, $x = 6{,}43\ \text{m}$, $y = 7{,}29\ \text{m}$
4.135. $\mathbf{F}_R = \{141\mathbf{i} + 100\mathbf{j} + 159\mathbf{k}\}\ \text{N}$,
$\mathbf{M}_{R_O} = \{122\mathbf{i} - 183\mathbf{k}\}\ \text{N} \cdot \text{m}$
4.137. $F_R = 990\ \text{N}$, $M_R = 3{,}07\ \text{kN} \cdot \text{m}$,
$x = 1{,}16\ \text{m}$, $y = 2{,}06\ \text{m}$
4.138. $F_R = 108\ \text{lb}$, $M_R = -624\ \text{lb} \cdot \text{pés}$,
$z = 8{,}69$ pés, $y = 0{,}414$ pé
4.139. $F_{RO} = 13{,}2\ \text{lb}\ \downarrow$, $x = 0{,}340$ pés
4.141. $F_R = 51{,}0\ \text{kN}\ \downarrow$, $M_{R_O} = 914\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.142. $F_R = 51{,}0\ \text{kN}\ \downarrow$, $d = 17{,}9\ \text{m}$
4.143. $F_R = 3{,}25\ \text{kip}$, $\theta = 67{,}2°\ \nearrow$, $x = 3{,}86$ pés
4.145. $F_R = 18{,}0\ \text{kip}\ \downarrow$, $x = 11{,}7$ pés
4.146. $F_R = 1{,}10\ \text{kN}\ \downarrow$, $M_{R_O} = 3{,}10\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.147. $d = 1{,}50\ \text{m}$, $w = 175\ \text{N/m}$
4.149. $F_R = 3{,}90\ \text{kip}\ \uparrow$, $d = 11{,}3$ pés
4.150. $b = 4{,}50$ pés, $a = 9{,}75$ pés
4.151. $F_R = 10{,}6\ \text{kip}\ \downarrow$, $x = 0{,}479$ pé
4.153. $F_R = 1{,}35\ \text{kN}$, $\theta = 42{,}0°\ \nearrow$, $x = 0{,}556\ \text{m}$
4.154. $F_R = 95{,}6\ \text{kN}\ \rightarrow$, $M_{R_O} = 349\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.155. $F_R = 107\ \text{kN}\ \leftarrow$, $h = 1{,}60\ \text{m}$
4.157. $F_R = 3{,}60\ \text{kN}\ \downarrow$, $M_{R_O} = 19{,}4\ \text{kN} \cdot \text{m}\ \curvearrowright$
4.158. $F_R = 80{,}6\ \text{kip}\ \uparrow$, $\bar{x} = 14{,}6$ pés
4.159. $F_R = 1{,}87\ \text{kip}\ \downarrow$, $\bar{x} = 3{,}66$ pol
4.161. $\alpha = 70{,}8°$, $\beta = 39{,}8°$, $\gamma = 56{,}7°$ ou
$\alpha = 109°$, $\beta = 140°$, $\gamma = 123°$
4.162. $\mathbf{M}_O = \{298\mathbf{i} + 15{,}1\mathbf{j} - 200\mathbf{k}\}\ \text{lb} \cdot \text{pol}$
4.163. $P = 23{,}8\ \text{lb}$
4.165. $\mathbf{M}_{a-a} = 59{,}7\ \text{N} \cdot \text{m}$
4.166. $\mathbf{M}_{CR} = \{63{,}6\mathbf{i} - 170\mathbf{j} + 264\mathbf{k}\}\ \text{N} \cdot \text{m}$
4.167. $\mathbf{F}_R = \{14{,}3\mathbf{i} + 21{,}4\mathbf{j} - 42{,}9\mathbf{k}\}\ \text{lb}$,
$\mathbf{M}_A = \{-1{,}93\mathbf{i} + 0{,}429\mathbf{j} - 0{,}429\mathbf{k}\}\ \text{kip} \cdot \text{pés}$
4.169. $\mathbf{M}_O = \{1{,}06\mathbf{i} + 1{,}06\mathbf{j} - 4{,}03\mathbf{k}\}\ \text{N} \cdot \text{m}$,
$\alpha = 75{,}7°$, $\beta = 75{,}7°$, $\gamma = 160°$
4.170. $\mathbf{F}_R = \{-70\mathbf{i} + 140\mathbf{j} - 408\mathbf{k}\}\ \text{N}$,
$\mathbf{M}_{RP} = \{-26\mathbf{i} + 357\mathbf{j} + 127\mathbf{k}\}\ \text{N} \cdot \text{m}$

Capítulo 5

5.11. $N_B = 245\ \text{N}$, $N_A = 425\ \text{N}$

5.13. $T_{AB} = 5{,}89$ kN, $C_x = 5{,}11$ kN, $C_y = 4{,}05$ kN
5.14. $T_{BC} = 11{,}1$ kip, $A_x = 10{,}2$ kip, $A_y = 6{,}15$ kip
5.15. $N_B = 2{,}14$ kip, $A_x = 1{,}29$ kip, $A_y = 1{,}49$ kip
5.17. $N_C = 493$ N, $N_B = 554$ N, $N_A = 247$ N
5.18. $B_y = 642$ N, $A_x = 192$ N, $A_y = 180$ N
5.19. $B_y = 586$ N, $F_A = 413$ N
5.21. $F_A = 30$ lb, $F_B = 36{,}2$ lb, $F_C = 9{,}38$ lb
5.22. $F_H = 59{,}4$ lb, $T_B = 67{,}4$ lb
5.23. $F_{CD} = 195$ lb, $A_x = 97{,}4$ lb, $A_y = 31{,}2$ lb
5.25. $(N_A)_r = 98{,}6$ lb, $(N_A)_t = 100$ lb
5.26. $N_B = 10{,}5$ N, $A_x = 42{,}0$ N, $A_y = 10{,}5$ N
5.27. $W_B = 78{,}6$ lb
5.29. $F_B = 6{,}38$ N, $A_x = 3{,}19$ N, $A_y = 2{,}48$ N
5.30. $F_{BC} = 574$ lb, $A_x = 1{,}08$ kip, $A_y = 637$ lb
5.31. $A_x = 1462$ lb, $F_B = 1{,}66$ kip
5.33. $D_x = 0$, $D_y = 1{,}65$ kip, $M_D = 1{,}40$ kip · pés
A linha de 800 lb criará a condição.
5.34. $x = 10$ pés, $A_x = 4{,}17$ kip, $A_y = 5{,}00$ kip
$x = 4$ pés, $A_x = 1{,}67$ kip, $A_y = 5{,}00$ kip
5.35. $F_B = 105$ N
5.37. $F = 311$ kN, $A_x = 460$ kN, $A_y = 7{,}85$ kN
5.38. $h = 15{,}8$ pés
5.39. $N_A = 81{,}6$ lb, $F_B = 50{,}2$ lb
5.41. $B_x = 989$ N, $A_x = 989$ N, $B_y = 186$ N
5.42. $w_1 = 413$ kN/m, $w_2 = 407$ kN/m
5.43. $T = 5$ kN, $T_{BC} = 16{,}4$ kN, $F_A = 20{,}6$ kN
5.45. $R_A = 40{,}9$ kip, $R_B = 125$ kip
5.46. $C_x = 333$ lb, $C_y = 722$ lb
5.47. **a)** $N_A = 2{,}19$ kip, $N_B = 1{,}16$ kip,
b) $W = 4{,}74$ kip
5.49. $F_2 = 724$ lb, $F_1 = 1{,}45$ kip, $F_A = 1{,}75$ kip
5.50. $d = \dfrac{3a}{4}$
5.51. $N_B = 2{,}11$ N, $F_A = 2{,}81$ N
5.53. $k = 11{,}2$ lb/pé
5.54. $R_A = 26{,}0$ lb, $R_B = 11{,}9$ lb, $R_C = 63{,}9$ lb
5.55. $\alpha = 1{,}02°$
5.57. $d = \dfrac{a}{\cos^3\theta}$
5.58. $\theta = \text{tg}^{-1}\dfrac{b}{a}$
5.59. $\alpha = 10{,}4°$
5.62. $\theta = 27{,}1°$ ou $\theta = 50{,}2°$
5.63. $T = 1{,}84$ kN, $F = 6{,}18$ kN
5.65. $T_B = 2{,}75$ kip, $T_C = 1{,}375$ kip, $T_A = 1{,}375$ kip
5.66. $W = 750$ lb, $x = 5{,}20$ pés, $y = 5{,}27$ pés
5.67. $F_A = 663$ lb, $F_C = 569$ lb, $F_B = 449$ lb
5.69. $N_C = 289$ N, $N_A = 213$ N, $N_B = 332$ N
5.70. $A_x = 0$, $A_y = 1{,}50$ kip, $A_z = 750$ lb, $T = 919$ lb
5.71. $F = 1{,}31$ kip, $A_x = 0$, $A_y = 1{,}31$ kip, $A_z = 653$ lb
5.73. $P = 75$ lb, $A_y = 0$, $A_z = 75$ lb, $B_z = 75$ lb,
$B_x = 112$ lb, $A_x = 37{,}5$ lb
5.74. $O_x = 0$, $O_y = -84{,}9$ lb, $O_z = 80{,}0$ lb,
$(M_O)_x = 948$ lb · pés, $(M_O)_y = 0$, $(M_O)_z = 0$
5.75. $F_{BC} = 0$, $A_y = 0$, $A_z = 800$ lb,
$(M_A)_x = 4{,}80$ kip · pés, $(M_A)_y = 0$, $(M_A)_z = 0$
5.77. $T = 58{,}0$ N, $C_z = 87{,}0$ N, $C_y = 28{,}8$ N,
$D_x = 0$, $D_y = 79{,}2$ N, $D_z = 58{,}0$ N
5.78. $T = 58{,}0$ N, $C_z = 77{,}6$ N, $C_y = 24{,}9$ N,
$D_x = 0$, $D_y = 68{,}5$ N, $D_z = 32{,}1$ N
5.79. $A_x = 633$ lb, $A_y = -141$ lb, $B_x = -721$ lb,
$B_z = 895$ lb, $C_y = 200$ lb, $C_z = -506$ lb
5.81. $B_z = 1167$ lb, $C_z = 734$ lb, $A_z = 1600$ lb
5.82. $T_{DE} = 32{,}1$ lb, $T_{BC} = 42{,}9$ lb, $A_x = 3{,}57$ lb,
$A_y = 50$ lb, $(M_A)_x = 0$, $(M_A)_y = -17{,}9$ lb · pés
5.83. $T_B = 16{,}7$ kN, $A_x = 0$, $A_y = 5{,}00$ kN,
$A_z = 16{,}7$ kN
5.85. $T_B = 25$ lb, $A_x = 25$ lb, $A_y = -25$ lb,
$A_z = 50$ lb, $B_y = 25$ lb
5.86. $B_z = 25{,}0$ lb, $P = 62{,}5$ lb, $B_x = 22{,}3$ lb,
$A_x = 84{,}8$ lb, $B_y = 0$, $A_z = 25{,}0$ lb
5.87. $F_{AC} = F_{BC} = 6{,}13$ kN, $F_{DE} = 19{,}6$ kN
5.89. $A_x = 0$, $A_y = 0$, $A_z = 589$ lb
5.90. $F_{BC} = 205$ N, $F_{ED} = 629$ N
$A_x = 32{,}4$ N, $A_y = 107$ N, $A_z = 1{,}28$ kN
5.91. $F_{CD} = 1{,}02$ kN, $A_z = -208$ N, $B_z = -139$ N,
$A_y = 573$ N, $B_y = 382$ N
5.93. $F = 354$ N
5.94. $N_A = 8{,}00$ kN, $B_x = 5{,}20$ kN, $B_y = 5{,}00$ kN
5.95. $N_B = 400$ N, $F_A = 721$ N
5.97. $N_B = 957$ N, $A_y = 743$ N, $A_x = 0$
5.98. $A_x = 0$, $A_y = 0$, $A_z = B_z = C_z = 5{,}33$ lb
5.99. $A_x = 0$, $A_y = -200$ N, $A_z = 150$ N,
$(M_A)_x = -100$ N · m, $(M_A)_y = 0$,
$(M_A)_z = -500$ N · m

Capítulo 6

6.1. $F_{BA} = 286$ lb (T), $F_{BC} = 808$ lb (T),
$F_{CA} = 571$ lb (C)
6.2. $F_{BA} = 286$ lb (T), $F_{BC} = 384$ lb (T),
$F_{CA} = 271$ lb (C)
6.3. $F_{AD} = 849$ lb (C), $F_{AB} = 600$ lb (T),
$F_{BD} = 400$ lb (C), $F_{BC} = 600$ lb (T),
$F_{DC} = 1{,}41$ kip (T), $F_{DE} = 1{,}60$ kip (C)
6.5. $F_{AE} = 8{,}94$ kN (C), $F_{AB} = 8{,}00$ kN (T),
$F_{BC} = 8{,}00$ kN (T), $F_{BE} = 8{,}00$ kN (C),
$F_{EC} = 8{,}94$ kN (T), $F_{ED} = 17{,}9$ kN (C)
6.6. $F_{AE} = 372$ N (C), $F_{AB} = 332$ N (T),
$F_{BC} = 332$ N (T), $F_{BE} = 196$ N (C),
$F_{EC} = 558$ N (T), $F_{ED} = 929$ N (C),
$F_{DC} = 582$ N (T)
6.7. $F_{BC} = 3$ kN (C), $F_{BA} = 8$ kN (C),
$F_{AC} = 1{,}46$ kN (C), $F_{AF} = 4{,}17$ kN (T),
$F_{CD} = 4{,}17$ kN (C), $F_{CF} = 3{,}12$ kN (C),

$F_{EF} = 0$, $F_{ED} = 13{,}1$ kN (C),
$F_{DF} = 5{,}21$ kN (T)

6.9. $F_{CB} = 8{,}00$ kN (T), $F_{CD} = 6{,}93$ kN (C),
$F_{DE} = 6{,}93$ kN (C), $F_{DB} = 4{,}00$ kN (T),
$F_{BE} = 4{,}00$ kN (C), $F_{BA} = 12{,}0$ kN (T)

6.10. $F_{AG} = 471$ lb (C), $F_{AB} = 333$ lb (T),
$F_{BG} = 0$, $F_{BC} = 333$ lb (T),
$F_{DE} = 943$ lb (C), $F_{DC} = 667$ lb (T),
$F_{EC} = 667$ lb (T), $F_{EG} = 667$ lb (C),
$F_{CG} = 471$ lb (T)

6.11. $F_{AG} = 1179$ lb (C), $F_{AB} = 833$ lb (T),
$F_{BC} = 833$ lb (T), $F_{BG} = 500$ lb (T),
$F_{DE} = 1650$ lb (C), $F_{DC} = 1167$ lb (T),
$F_{EC} = 1167$ lb (T), $F_{EG} = 1167$ lb (C),
$F_{CG} = 471$ lb (T)

6.13. $F_{GB} = 30$ kN (T), $F_{AF} = 20$ kN (C),
$F_{AB} = 22{,}4$ kN (C), $F_{BF} = 20$ kN (T),
$F_{BC} = 20$ kN (T), $F_{FC} = 28{,}3$ kN (C), $F_{FE} = 0$,
$F_{ED} = 0$, $F_{EC} = 20{,}0$ kN (T), $F_{DC} = 0$

6.14. $F_{AB} = 330$ lb (C), $F_{AF} = 79{,}4$ lb (T),
$F_{BF} = 233$ lb (T), $F_{BC} = 233$ lb (C),
$F_{FC} = 47{,}1$ lb (C), $F_{FE} = 113$ lb (T),
$F_{EC} = 300$ lb (T), $F_{ED} = 113$ lb (T),
$F_{CD} = 377$ lb (C)

6.15. $F_{AB} = 377$ lb (C), $F_{AF} = 190$ lb (T),
$F_{BF} = 267$ lb (T), $F_{BC} = 267$ lb (C),
$F_{FC} = 189$ lb (T), $F_{FE} = 56{,}7$ lb (T),
$F_{ED} = 56{,}7$ lb (T), $F_{EC} = 0$,
$F_{CD} = 189$ lb (C)

6.17. $P = 5{,}20$ kN

6.18. $F_{CB} = 400$ lb (C), $F_{CD} = 693$ lb (C),
$F_{BD} = 667$ lb (T), $F_{BA} = 1{,}13$ kip (C)

6.19. $F_{CD} = 3{,}61$ kN (C), $F_{CB} = 3$ kN (T),
$F_{BA} = 3$ kN (T), $F_{BD} = 3$ kN (C),
$F_{DA} = 2{,}70$ kN (T), $F_{DE} = 6{,}31$ kN (C)

6.21. $F_{BA} = P\,\text{cosec}\,2\theta$(C), $F_{BC} = P\,\text{cotg}\,2\theta$(C),
$F_{CA} = (\text{cotg}\,\theta\,\text{cosec}\,\theta - \text{sen}\,\theta + 2\,\text{cosec}\,\theta)P$ (T),
$F_{CD} = (\text{cotg}\,2\theta + 1)P$ (C),
$F_{DA} = (\text{cotg}\,2\theta + 1)(\text{cosec}\,2\theta)(P)$ (C)

6.22. $P_{máx} = 732$ N

6.23. $F_{DE} = 16{,}3$ kN (C), $F_{DC} = 8{,}40$ kN (T),
$F_{EA} = 8{,}85$ kN (C), $F_{EC} = 6{,}20$ kN (C),
$F_{CF} = 8{,}77$ kN (T), $F_{CB} = 2{,}20$ kN (T),
$F_{BA} = 3{,}11$ kN (T), $F_{BF} = 6{,}20$ kN (C),
$F_{FA} = 6{,}20$ kN (T)

6.25. $F_{AB} = 7{,}5$ kN (T), $F_{AE} = 4{,}5$ kN (C),
$F_{ED} = 4{,}5$ kN (C), $F_{EB} = 8$ kN (T),
$F_{BD} = 19{,}8$ kN (C), $F_{BC} = 18{,}5$ kN (T)

6.26. $F_{AB} = 196$ N (T), $F_{AE} = 118$ N (C),
$F_{ED} = 118$ N (C), $F_{EB} = 216$ N (T),
$F_{BD} = 1{,}04$ kN (C), $F_{BC} = 857$ N (T)

6.27. $F_{CB} = F_{CD} = 0$, $F_{AB} = 2{,}40P$ (C),
$F_{AF} = 2{,}00P$ (T), $F_{BF} = 1{,}86P$ (T),
$F_{BD} = 0{,}373P$ (C),
$F_{FE} = 1{,}86P$ (T), $F_{FD} = 0{,}333P$ (T)
$F_{DE} = 0{,}373P$ (C)

6.29. $127° \leq \theta \leq 196°$, $336° \leq \theta \leq 347°$

6.30. $F_{HG} = 29{,}0$ kN (C), $F_{BC} = 20{,}5$ kN (T),
$F_{HC} = 12{,}0$ kN (T)

6.31. $F_{GF} = 29{,}0$ kN (C), $F_{CD} = 23{,}5$ kN (T),
$F_{CF} = 7{,}78$ kN (T)

6.33. $F_{KJ} = 13{,}3$ kN (T), $F_{BC} = 14{,}9$ kN (C),
$F_{CK} = 0$

6.34. $F_{KJ} = 11{,}2$ kip (T), $F_{CD} = 9{,}38$ kip (C),
$F_{CJ} = 3{,}12$ kip (C), $F_{DJ} = 0$

6.35. $F_{JI} = 7{,}50$ kip (T), $F_{EJ} = 2{,}50$ kip (C)

6.37. $F_{FG} = 8{,}08$ kN (T), $F_{CD} = 8{,}47$ kN (C),
$F_{CF} = 0{,}770$ kN (T)

6.38. $F_{GF} = 671$ lb (C), $F_{GB} = 671$ lb (T)

6.39. $F_{BG} = -200\sqrt{L^2 + 9}$,
$F_{BC} = -200L$, $F_{HG} = 400L$

6.41. *AB*, *BC*, *CD*, *DE*, *HI*, e *GI* são elementos com força nula.
$F_{JE} = 9{,}38$ kN (C), $F_{GF} = 5{,}625$ kN (T)

6.42. $F_{BC} = 10{,}4$ kN (C), $F_{HG} = 9{,}16$ kN (T),
$F_{HC} = 2{,}24$ kN (T)

6.43. $F_{CD} = 11{,}2$ kN (C), $F_{CF} = 3{,}21$ kN (T),
$F_{CG} = 6{,}80$ kN (C)

6.45. $F_{GJ} = 2{,}00$ kip (C)

6.46. $F_{GC} = 1{,}00$ kip (T)

6.47. $F_{GF} = 1{,}78$ kN (T), $F_{CD} = 2{,}23$ kN (C),
$F_{CF} = 0$

6.49. $F_{EF} = P$ (C), $F_{CB} = 1{,}12P$ (T), $F_{BE} = 0{,}5P$ (T)

6.50. $F_{AB} = P$ (T), $F_{EF} = P$ (C), $F_{BF} = 1{,}41P$ (C)

6.51. *BN*, *NC*, *DO*, *OC*, *HJ*, *LE* e *JG* são elementos com força nula.
$F_{CD} = 5{,}625$ kN (T), $F_{CM} = 2{,}00$ kN (T)

6.53. $F_{KJ} = 3{,}07$ kip (C), $F_{CD} = 3{,}07$ kip (T)
$F_{ND} = 0{,}167$ kip (T), $F_{NJ} = 0{,}167$ kip (C)

6.54. $F_{JI} = 2{,}13$ kip (C), $F_{DE} = 2{,}13$ kip (T)

6.55. $F_{AD} = 300$ lb (C), $F_{BD} = 450$ lb (C),
$F_{CD} = 568$ lb (C)

6.57. $F_{DC} = F_{DA} = 2{,}59$ kN (C), $F_{DB} = 3{,}85$ kN (C)
$F_{BC} = F_{BA} = 0{,}890$ kN (T), $F_{AC} = 0{,}616$ kN (T)

6.58. $F_{BF} = 0$, $F_{BC} = 0$,
$F_{BE} = 500$ lb (T), $F_{AB} = 300$ lb (C),
$F_{AC} = 583$ lb (T), $F_{AD} = 333$ lb (T),
$F_{AE} = 667$ lb (C), $F_{DE} = 0$,
$F_{EF} = 300$ lb (C), $F_{CD} = 300$ lb (C),
$F_{CF} = 300$ lb (C), $F_{DF} = 424$ lb (T)

6.59. $F_{BF} = 0$, $F_{BC} = 0$, $F_{BE} = 500$ lb (T),
$F_{AB} = 300$ lb (C), $F_{AC} = 972$ lb (T), $F_{AD} = 0$,
$F_{AE} = 367$ lb (C), $F_{DE} = 0$, $F_{EF} = 300$ lb (C),
$F_{CD} = 500$ lb (C), $F_{CF} = 300$ lb (C),
$F_{DF} = 424$ lb (T)

6.61. $F_{BC} = F_{BD} = 1{,}34$ kN (C),
$F_{AB} = 2{,}4$ kN (C), $F_{AG} = F_{AE} = 1{,}01$ kN (T),
$F_{BG} = 1{,}80$ kN (T), $F_{BE} = 1{,}80$ kN (T)

6.62. $F_{BC} = 1{,}15$ kN (C), $F_{DF} = 4{,}16$ kN (C), $F_{BE} = 4{,}16$ kN (T)
6.63. $F_{CF} = 0$, $F_{CD} = 2{,}31$ kN (T), $F_{ED} = 3{,}46$ kN (T), $F_{AB} = 3{,}46$ kN (C)
6.65. $F_{BC} = 0$, $F_{CD} = 0$, $F_{CF} = 8$ kN (C), $F_{BD} = 0$, $F_{BA} = 6$ kN (C), $F_{AD} = 0$, $F_{DF} = 0$, $F_{DE} = 9$ kN (C), $F_{EF} = 0$, $F_{EA} = 0$, $F_{AF} = 0$
6.66. **a)** $P = 25{,}0$ lb, **b)** $P = 33{,}3$ lb, **c)** $P = 11{,}1$ lb
6.67. $F_B = 61{,}9$ lb, $F_A = 854$ lb
6.69. $R_E = 177$ lb, $R_A = 128$ lb
6.70. $P = 40{,}0$ N, $x = 240$ mm
6.71. $P = 21{,}8$ N, $R_A = 43{,}6$ N, $R_B = 43{,}6$ N, $R_C = 131$ N
6.73. $A_y = 9{,}59$ kip, $B_y = 8{,}54$ kip, $C_y = 2{,}93$ kip, $C_x = 9{,}20$ kip
6.74. $P = 743$ N
6.75. $A_y = 300$ N, $A_x = 300$ N, $C_x = 300$ N, $C_y = 300$ N
6.77. $B_y = 1{,}33$ kN, $B_x = 5{,}00$ kN, $A_x = C_x = 5{,}00$ kN, $A_y = C_y = 6{,}67$ kN $M_D = 10{,}0$ kN·m, $D_y = 8{,}00$ kN, $D_x = 0$
6.78. $C_x = 75$ lb, $C_y = 100$ lb
6.79. $A_x = 4{,}20$ kN, $B_x = 4{,}20$ kN, $A_y = 4{,}00$ kN, $B_y = 3{,}20$ kN, $C_x = 3{,}40$ kN, $C_y = 4{,}00$ kN
6.81. $T = 100$ lb, $\theta = 14{,}6°$
6.82. $x = 9{,}43$ pés
6.83. $T = 350$ lb, $A_y = 700$ lb, $A_x = 1{,}88$ kip, $D_x = 1{,}70$ kip, $D_y = 1{,}70$ kip
6.85. $A_x = 80$ lb, $A_y = 80$ lb, $B_y = 133$ lb, $B_x = 333$ lb, $C_x = 413$ lb, $C_y = 53{,}3$ lb
6.86. $F_{AB} = 9{,}23$ kN, $C_x = 2{,}17$ kN, $C_y = 7{,}01$ kN, $D_x = 0$, $D_y = 1{,}96$ kN, $M_D = 2{,}66$ kN·m
6.87. $C_y = 34{,}4$ lb, $C_x = 16{,}7$ lb, $B_x = 66{,}7$ lb, $B_y = 15{,}6$ lb
6.89. $C_x = D_x = 160$ lb, $C_y = D_y = 107$ lb, $B_y = 26{,}7$ lb, $B_x = 80{,}0$ lb, $E_x = 0$, $E_y = 26{,}7$ lb, $A_x = 160$ lb
6.90. $F_E = 3{,}64F$
6.91. $A_y = 657$ N, $C_y = 229$ N, $C_x = 0$, $B_x = 0$, $B_y = 429$ N
6.93. $m = 366$ kg, $F_A = 2{,}93$ kN
6.94. $M = 314$ lb·pés
6.95. $P = 46{,}9$ lb
6.97. $A_y = 34{,}0$ N, $A_x = 0$, $C_y = 6{,}54$ N, $C_x = 0$, $x = 292$ mm, $B_y = 1{,}06$ N, $B_x = 0$
6.98. $F_{DE} = 1{,}07$ kN
6.99. $C_y = 1{,}33$ kN, $B_y = 549$ N, $C_x = 2{,}98$ kN, $A_y = 235$ N, $A_x = 2{,}98$ kN, $B_x = 2{,}98$ kN
6.101. $F = 9{,}42$ lb
6.102. $F_{AC} = 2{,}51$ kip, $F_{AB} = 3{,}08$ kip, $F_{AD} = 3{,}43$ kip
6.103. $W_C = 0{,}812W$
6.105. $B_y = 940$ lb, $A_y = 360$ lb, $M_C = 7{,}80$ kip·pés, $C_y = 900$ lb, $C_x = 250$ lb
6.106. $N_C = 20$ lb, $B_x = 34$ lb, $B_y = 62$ lb, $A_x = 34$ lb, $A_y = 12$ lb, $M_A = 336$ lb·pés
6.107. $E_x = 6{,}79$ kN, $E_y = 1{,}55$ kN, $D_x = 981$ N, $D_y = 981$ N
6.109. $\theta = \text{sen}^{-1}\left(\dfrac{8W}{kL}\right)$
6.110. $1{,}75 \text{ pés} \leq x \leq 17{,}4$ pés
6.111. $F_D = 20{,}8$ lb, $F_F = 14{,}7$ lb, $F_A = 24{,}5$ lb
6.113. **a)** $F = 175$ lb, $N_C = 350$ lb
b) $F = 87{,}5$ lb, $N_C = 87{,}5$ lb
6.114. **a)** $F = 205$ lb, $N_C = 380$ lb
b) $F = 102$ lb, $N_C = 72{,}5$ lb
6.115. $M = 14{,}2$ lb·pés
6.117. $F_{AB} = 981$ N, $F_E = 2{,}64$ kN, $F_{CD} = 16{,}3$ kN, $F_F = 14{,}0$ kN
6.118. $x = 4{,}38$ pol
6.119. $P = 3000$ psi
6.121. $T_{AI} = 2{,}88$ kip, $F_H = 3{,}99$ kip
6.122. $F_{CA} = 12{,}9$ kip, $F_{AB} = 11{,}9$ kip, $F_{AD} = 2{,}39$ kip
6.123. $W_1 = 3$ lb, $W_2 = 21$ lb, $W_3 = 75$ lb
6.125. $P_{máx} = 471$ N, $B_x = D_x = 283$ N, $B_y = D_y = 283$ N, $B_z = D_z = 0$
6.126. $F_{AB} = 1{,}56$ kN, $M_{Ex} = 0{,}5$ kN·m, $M_{Ey} = 0$, $E_y = 0$, $E_x = 0$, $F_{BE} = 1{,}53$ kip, $F_{CD} = 350$ lb
6.127. $M_{Cx} = 0$, $C_x = 0$, $F_{BA} = 1{,}54$ kip, $C_z = -0{,}18$ kip, $C_y = -1{,}17$ kip, $M_{Cz} = -4{,}14$ kip·pés, $A_x = 0$, $A_y = 1{,}44$ kip, $A_z = 0{,}540$ kip
6.129. $\theta = 16{,}1°$
6.130. $A_x = 1{,}40$ kN, $A_y = 250$ N, $C_x = 500$ N, $C_y = 1{,}70$ kN
6.131. $\theta = 21{,}7°$
6.133. $B_x = B_y = 220$ N, $A_x = 300$ N, $A_y = 80{,}4$ N
6.134. $A_x = 117$ N, $A_y = 397$ N, $B_x = 97{,}4$ N, $B_y = 97{,}4$ N
6.135. $P = \dfrac{kL}{2 \text{tg}\,\theta \,\text{sen}\,\theta}(2 - \text{cosec}\,\theta)$
6.137. $F_{AD} = 2{,}47$ kip (T), $F_{AC} = F_{AB} = 1{,}22$ kip (C)

Capítulo 7

7.1. $V_A = 0$, $N_A = 12{,}0$ kN, $M_A = 0$, $V_B = 0$, $N_B = 20{,}0$ kN, $M_B = 1{,}20$ kN·m
7.2. $N_A = 550$ lb, $N_B = 250$ lb, $N_C = 950$ lb
7.3. $N_A = 5{,}00$ kN, $N_C = 4{,}00$ kN, $N_B = 3{,}00$ kN
7.5. $M_C = -15{,}0$ kip·pés, $N_C = 0$, $V_C = 2{,}01$ kip, $M_D = 3{,}77$ kip·pés, $N_D = 0$, $V_D = 1{,}11$ kip
7.6. $N_C = 0$, $V_C = -1{,}00$ kip, $M_C = 56{,}0$ kip·pés, $N_D = 0$, $V_D = -1{,}00$ kip, $M_D = 48{,}0$ kip·pés
7.7. $N_C = 0$, $V_C = -386$ lb, $M_C = -857$ lb·pés, $N_D = 0$, $V_D = 300$ lb, $M_D = -600$ lb·pés

7.9. $N_D = -800$ N, $V_D = 0$, $M_D = 1{,}20$ kN · m

7.10. $w = 100$ N/m

7.11. $M_C = 48$ kip · pés, $V_C = 6$ kip

7.13. $N_D = 0$, $V_D = 800$ lb, $M_D = -1{,}60$ kip · pés,
$N_C = 0$, $V_C = 0$, $M_C = 800$ lb · pés

7.14. $N_D = 1{,}92$ kN, $V_D = 100$ N, $M_D = 900$ N · m

7.15. $N_E = -1{,}92$ kN, $V_E = 800$ N, $M_E = 2{,}40$ kN · m

7.17. $N_C = -406$ lb, $V_C = 903$ lb, $M_C = 1{,}35$ kip · pés

7.18. $N_D = -464$ lb, $V_D = -203$ lb, $M_D = 2{,}61$ kip · pés

7.19. $N_C = -30$ kN, $V_C = -8$ kN, $M_C = 6$ kN · m

7.21. $N_B = 0$, $V_B = 28{,}8$ kip, $M_B = -115$ kip · pés

7.22. $\dfrac{a}{b} = \dfrac{1}{4}$

7.23. $N_C = 20{,}0$ kN, $V_C = 70{,}6$ kN, $M_C = -302$ kN · m

7.25. $M_C = -17{,}8$ kip · pés

7.26. $N_D = 0$, $V_D = 0{,}75$ kip, $M_D = 13{,}5$ kip · pés,
$N_E = 0$, $V_E = -9$ kip, $M_E = -24{,}0$ kip · pés

7.27. $N_D = 2{,}40$ kN, $V_D = 50$ N, $M_D = 1{,}35$ kN · m

7.29. $V_C = 2{,}49$ kN, $N_C = 2{,}49$ kN, $M_C = 4{,}97$ kN · m,
$N_D = 0$, $V_D = -2{,}49$ kN, $M_D = 16{,}5$ kN · m

7.30. $N_B = 59{,}8$ lb, $V_B = -496$ lb, $M_B = -480$ lb · pés,
$N_C = -495$ lb, $V_C = 70{,}7$ lb, $M_C = -1{,}59$ kip · pé

7.31. $N_A = 86{,}6$ lb, $V_A = 150$ lb, $M_A = 1800$ lb · pol

7.33. $N_D = 0$, $V_D = 0$, $M_D = 9{,}00$ kN · m,
$N_E = 0$, $V_E = -7{,}00$ kN, $M_E = -12{,}0$ kN · m

7.34. $V_E = 0$, $N_E = 894$ N, $M_E = 0$, $V_F = 447$ N,
$N_F = 224$ N, $M_F = 224$ N · m

7.35. $a = \dfrac{L}{3}$

7.37. $N = -0{,}866rw_0$, $V = -1{,}5rw_0$, $M = 1{,}23r^2w_0$

7.38. $C_x = -150$ lb, $C_y = -350$ lb, $C_z = 700$ lb
$M_{Cx} = 1{,}40$ kip · pé, $M_{Cy} = -1{,}20$ kip · pé,
$M_{Cz} = -750$ lb · pés

7.39. $C_x = -170$ lb, $C_y = -50$ lb, $C_z = 500$ lb
$M_{Cx} = 1$ kip · pé, $M_{Cy} = -900$ lb · pés,
$M_{Cz} = -260$ lb · pés

7.41. $N_C = -350$ lb, $(V_C)_y = 700$ lb, $(V_C)_z = -150$ lb,
$(M_C)_x = -1{,}20$ kip · pé, $(M_C)_y = -750$ lb · pés,
$(M_C)_z = 1{,}40$ kip · pé

7.42. Para $0 \le x < a$: $V = \dfrac{Pb}{a+b}$, $M = \dfrac{Pb}{a+b}x$,

Para $a < x < a + b$: $V = -\dfrac{Pa}{a+b}$,

$M = Pa - \dfrac{Pa}{a+b}x$

7.43. Para $0 \le x < 5$ pés: $V = 100$, $M = 100x - 1800$
Para $5 < x \le 10$ pés: $V = 100$, $M = 100x - 1000$

7.45. Para $0 \le x < \dfrac{L}{3}$: $V = 0$, $M = 0$

Para $\dfrac{L}{3} < x < \dfrac{2L}{3}$: $V = 0$, $M = M_0$

Para $\dfrac{2L}{3} < x \le L$: $V = 0$, $M = 0$

Para $0 \le x < \dfrac{8}{3}$ m: $V = 0$, $M = 0$

Para $\dfrac{8}{3}$ m $< x < \dfrac{16}{3}$ m: $V = 0$, $M = 500$ N · m

Para $\dfrac{16}{3}$ m $< x \le 8$ m: $V = 0$, $M = 0$

7.46. $M_0 = 2$ kN · m

7.47. $w = 400$ lb/pé

7.49. Para $0 \le x < 20$ pés: $V = \{490 - 50{,}0x\}$ lb,
$M = \{490x - 25{,}0x^2\}$ lb · pés,
Para 20 pés $< x \le 30$ pés:
$V = 0$, $M = -200$ lb · pés

7.50. Para $0 \le x \le \dfrac{L}{2}$: $V = \dfrac{wL}{8}$, $M = \dfrac{wL}{8}x$,

Para $\dfrac{L}{2} < x \le L$: $V = \dfrac{w}{8}(5L - 8x)$,

$M = \dfrac{w}{8}(-L^2 + 5Lx - 4x^2)$

7.51. $V = 250(10 - x)$, $M = 25(100x - 5x^2 - 6)$

7.53. **Segmento AB**:
Para $0 \le x < 12$ pés:
$V = \{875 - 150x\}$ lb,
$M = \{875x - 75{,}0x^2\}$ lb · pés,
Para $12 < x \le 14$ pés:
$V = \{2100 - 150x\}$ lb,
$M = \{-75{,}0x^2 + 2100x - 14700\}$ lb · pés,
Segmento CD:
Para $0 \le x < 2$ pés: $V = 919$ lb,
$M = 919x$ lb · pés
Para $2 < x \le 8$ pés: $V = 306$ lb,
$M = \{2450 - 306x\}$ lb · pés

7.54. $V = \dfrac{w}{4}(3L - 4x)$, $M = \dfrac{w}{4}(3Lx - 2x^2 - L^2)$

7.55. Para $0 \le x < L$: $V = \dfrac{w}{18}(7L - 18x)$,
$M = \dfrac{w}{18}(7Lx - 9x^2)$, para $L < x < 2L$:
$V = \dfrac{w}{2}(3L - 2x)$, $M = \dfrac{w}{18}(27Lx - 20L^2 - 9x^2)$,
para $2L < x \le 3L$: $V = \dfrac{w}{18}(47L - 18x)$,
$M = \dfrac{w}{18}(47Lx - 9x^2 - 60L^2)$

7.57. $w = 22{,}2$ lb/pé

7.58. $x = \dfrac{L}{2}$, $P = \dfrac{4M_{máx}}{L}$

7.59. Para $0 \le x \le 12$ pés: $V = \left\{48{,}0 - \dfrac{x^2}{6}\right\}$ kip,

$M = \left\{48{,}0x - \dfrac{x^3}{18} - 576\right\}$ kip · pés

Para $12 < x \le 24$ pés: $V = \left\{\dfrac{1}{6}(24 - x)^2\right\}$ kip,

$M = \left\{-\dfrac{1}{18}(24 - x)^3\right\}$ kip · pés

7.61. $V = \frac{w}{12L}(4L^2 - 6Lx - 3x^2)$,
$M = \frac{w}{12L}(4L^2x - 3Lx^2 - x^3)$, $M_{máx} = 0{,}0940wL^2$

7.62. Para $0 \le x < a$: $V = P$, $M = Px$,
Para $a < x < L - a$: $V = 0$, $M = Pa$,
Para $L - a < x \le L$: $V = -P$, $M = P(L - x)$
$V = 800$ lb, $M = 800x$ lb · pés, $V = 0$,
$M = 4000$ lb · pés, $V = -800$ lb,
$M = (9600 - 800x)$ lb · pés

7.63. $V_x = 1{,}5$ kip, $V_y = 0$, $V_z = 800(4 - y)$ lb,
$M_x = 400(4 - y)^2$ lb · pés, $M_y = -3$ kip · pés,
$M_z = -1500(4 - y)$ lb · pés

7.65. $V_x = 0$, $V_z = \{24{,}0 - 4y\}$ lb,
$M_x = \{2y^2 - 24y + 64{,}0\}$ lb · pés,
$M_y = 8{,}00$ lb · pés, $M_z = 0$

7.78. $w = 2$ kip/pé

7.89. $F_{BC} = 46{,}7$ lb, $F_{BA} = 83{,}0$ lb, $F_{CD} = 88{,}1$ lb,
$l = 20{,}2$ pés

7.90. $F_{DC} = 43{,}7$ lb, $F_{DB} = 78{,}2$ lb, $F_{CA} = 74{,}7$ lb,
$l = 15{,}7$ pés

7.91. $y_B = 8{,}67$ pés, $y_D = 7{,}04$ pés

7.93. $x_B = 4{,}36$ pés

7.94. $P = 71{,}4$ lb

7.95. $P_1 = 2{,}50$ kN, $P_2 = 6{,}25$ kN, $F_{máx} = 12{,}5$ kN

7.97. $w = 51{,}9$ lb/pé

7.98. $T_{máx} = 14{,}4$ kip, $T_{min} = 13{,}0$ kip

7.99. $y = (38{,}5x^2 + 577x)(10^{-3})$ m, $T_{máx} = 5{,}20$ kN

7.101. $y = 2{,}37(10^{-3})x^3$, $T_{máx} = 4{,}42$ kip

7.102. $y = \frac{x^2}{7813}\left(75 - \frac{x^2}{200}\right)$ pés, $T_{máx} = 9{,}28$ kip

7.103. $h = 7{,}09$ m

7.105. $L = 302$ pés

7.107. $\frac{h}{L} = 0{,}141$

7.109. $(T_{máx})_B = 2{,}73$ kip, $(T_{máx})_C = 2{,}99$ kip

7.110. $T_{min} = 185$ lb, $h = 50{,}3$ pés

7.111. $T_{máx} = 170$ lb, $L = 150$ pés

7.113. Peso total $= 4{,}00$ kip, $T_{máx} = 2{,}01$ kip

7.114. $h = 6{,}21$ pés, $N_m = 306$ lb

7.115. $l = 238$ pés, $h = 93{,}75$ pés

7.117. $a = 0{,}366L$

7.119. Para $0 \le x < 3$ m: $V = 1{,}50$ kN,
$M = 1{,}50x$ kN · m, para $3 < x \le 6$m:
$V = -4{,}50$ kN, $M = \{27{,}0 - 4{,}50x\}$ kN · m

7.121. $N_C = 0$, $V_C = 9{,}00$ kN,
$M_C = -62{,}5$ kN · m,
$N_B = 0$, $V_B = 27{,}5$ kN,
$M_B = -184{,}5$ kN · m

7.122. $T_{máx} = 76{,}7$ lb

Capítulo 8

8.1. Em ambos os casos, $N_A = 16{,}5$ kN, $N_B = 42{,}3$ kN. Quando as rodas em A travam, o carrinho se move. Quando tanto as rodas em A quanto em B travam, o carrinho não se move.

8.2. $F_C = 27{,}4$ lb, $N_C = 309$ lb

8.3. O poste permanecerá nessa posição.

8.5. $P = 15$ lb

8.6. $P = 1$ lb

8.7. $N_C = 800$ lb, $N_B = 961$ lb

8.9. A escada não escorregará.

8.10. $P = \frac{M_0}{\mu_s ra}(b - \mu_s c)$

8.13. **a)** Não, **b)** Sim

8.14. **a)** Não, **b)** Sim

8.15. É possível puxar a carga sem provocar deslizamento ou elevação das rodas.

8.17. $P = 83{,}3$ lb

8.18. $P = 100$ lb

8.19. $m = 54{,}9$ kg

8.21. **a)** $W = 318$ lb, **b)** $W = 360$ lb

8.22. $F = 22{,}5$ lb, $\mu_b = 0{,}15$

8.23. $F = 30{,}4$ lb, $\mu_b = 0{,}195$

8.25. $d = 2{,}70$ pol

8.26. $\theta = 16{,}7°$, $\phi = 42{,}6°$

8.27. O carro A não se move.

8.29. $\theta = 16{,}7°$, $P = 0{,}287W$

8.30. O deslizamento ocorre em A.

8.31. $\theta = 11{,}0°$

8.33. $\mu_e = 0{,}268$

8.34. $L = 3{,}35$ pés

8.35. $P = 100$ lb, $d = 1{,}50$ pés

8.37. $F_D = 36{,}9$ lb, $A_y = 468$ lb, $B_x = 34{,}6$ lb,
$B_y = 228$ lb

8.38. $\theta = 10{,}6°$, $x = 0{,}184$ pés (estiramento)

8.39. $\theta = 8{,}53°$, $F_A = 1{,}48$ lb, $F_B = 0{,}890$ lb

8.41. $P = 63{,}5$ lb

8.42. $\mu = 0{,}176$

8.43. $P = 45{,}0$ lb, $\mu_e' = 0{,}300$

8.45. $P = 13{,}3$ lb

8.46. $M = 90{,}6$ N · m

8.47. $P = 355$ N

8.50. $\phi = \theta = \text{tg}^{-1}\mu$, $P = W \,\text{sen}(\alpha + \phi)$

8.51. $P = 107$ N

8.53. $P = 196$ N

8.54. $P = 40{,}2$ N

8.55. $P = \frac{1}{2}\mu_e W$

8.57. O cavalete da serra começa a deslizar.

8.58. O cavalete da serra começa a deslizar.

8.59. $M = 77{,}3$ N · m

8.61. $P = 375$ N

8.62. $P = 2{,}39$ kN

8.63. $W = 66{,}6$ lb

8.65. $P = 34{,}5$ N
8.66. $P = 304$ N
8.67. $x = 32{,}9$ mm
8.69. $P = 69{,}4$ lb
8.70. $P = 5{,}53$ kN
O calço é autobloqueante
8.71. $W = 7{,}19$ kN
8.73. $\mu_e = 0{,}0637$
8.74. $F = 620$ N
8.75. $M = 5{,}69$ lb · pol
8.77. $P = 1{,}98$ kN
8.78. $M = 0{,}202$ N · m
8.79. $M = 48{,}3$ N · m
8.81. $F_D = F_E = 72{,}7$ N
8.82. $A_x = 328{,}6$ N, $B_y = C_y = 164$ N
8.83. $F_{AB} = 1{,}38$ kN (T), $F_{BD} = 828$ N (C), $F_{BC} = 1{,}10$ kN (C), $F_{AC} = 828$ N (C), $F_{AD} = 1{,}10$ kN (C), $F_{CD} = 1{,}38$ kN (T)
8.85. $n = 2$ voltas
8.86. Cerca de 2 voltas (695°)
8.87. $W = 86{,}0$ lb, $W = 13{,}9$ lb
8.89. **a)** $F = 4{,}60$ kN, **b)** $F = 16{,}2$ kN
8.90. $n = 3$ meia-voltas, $N_h = 6{,}74$ lb
8.91. $P = 42{,}3$ N
8.93. $W_D = 12{,}7$ lb
8.94. $F_C = 13{,}7$ lb, $F_B = 38{,}5$ lb
8.97. $M = 3{,}37$ N · m
8.98. $P = 17{,}1$ lb
8.99. $P = 78{,}7$ lb
8.101. $h = 8{,}28$ pés
8.102. $M = 50{,}0$ N · m, $x = 286$ mm
8.103. $P = 223$ N
8.105. $m = 25{,}6$ kg
8.106. $m = 7{,}82$ kg
8.107. $M = 15{,}8$ lb · pés
8.109. $F_m = 1{,}62$ kip
8.110. $M = 36{,}3$ lb · pés
8.111. $F = 10{,}7$ lb
8.113. $M = 43{,}9$ lb · pés
8.114. $M = \frac{1}{2}\mu PR$
8.115. $M = 0{,}521\, P\mu R$
8.117. $M = 17{,}0$ N · m
8.118. $\theta = 68{,}2°$, $M = 0{,}0455$ N · m
8.119. $\mu = 0{,}215$, $F = 6$ lb
8.121. $T = 289$ lb, $N = 479$ lb, $F = 101$ lb
8.122. $\mu_e = 0{,}0407$
8.123. $F = 18{,}9$ N
8.125. $P = 13{,}8$ lb
8.126. $P = 29{,}0$ lb
8.127. $(r_f)_A = 0{,}2$ pol, $(r_f)_B = 0{,}075$ pol
8.129. $P \approx 78{,}8$ lb
8.130. $P = 245$ N
8.133. $F = 90{,}9$ lb
8.134. $s = 0{,}750$ m
8.135. **a)** $W = 6{,}97$ kN, **b)** $W = 15{,}3$ kN
8.137. A came não pode manter a vassoura.
8.138. $P = 60$ lb para duas caixas.
$P' = 90$ lb para três caixas.
8.139. $M = 2{,}50$ kip · pés

Capítulo 9

9.1. $\bar{x} = 0{,}546$ m, $O_x = 0$, $O_y = 7{,}06$ N, $M_O = 3{,}85$ N · m
9.2. $\bar{x} = 0$, $\bar{y} = 1{,}82$ pés
9.3. $\bar{x} = 124$ mm, $\bar{y} = 0$
9.5. $\bar{x} = 0{,}531$ pé, $O_x = 0$, $O_y = 0{,}574$ lb, $M_O = 0{,}305$ lb · pé
9.6. $\bar{y} = 0{,}183$ pé
9.7. $\bar{x} = \frac{3}{8}b$, $\bar{y} = \frac{3}{5}h$
9.9. $\bar{x} = \frac{3}{4}b$, $\bar{y} = \frac{3}{10}h$
9.10. $\bar{x} = \frac{5a}{8}$
9.11. $\bar{x} = \frac{n+1}{2(n+2)}a$
9.13. $\bar{x} = 3{,}20$ pés, $\bar{y} = 3{,}20$ pés, $T_A = 384$ lb, $T_C = 384$ lb, $T_B = 1{,}15$ kip
9.14. $\bar{x} = \frac{(n+1)}{2(n+2)}a$, $\bar{y} = \frac{n+1}{2(2n+1)}h$
9.15. $\bar{x} = \frac{n+1}{2(n+2)}a$, $\bar{y} = \frac{n}{2n+1}h$
9.17. $\bar{y} = \frac{4b}{3\pi}$, $\bar{x} = \frac{4a}{3\pi}$
9.18. $\bar{x} = \frac{\pi}{2}a$, $\bar{y} = \frac{\pi}{8}a$
9.19. $\bar{y} = 2{,}80$ m, $\bar{x} = 6{,}00$ m
9.21. $\bar{y} = 2{,}04$ pés
9.22. $\bar{x} = 1{,}26$ m, $\bar{y} = 0{,}143$ m, $N_B = 47{,}9$ kN, $A_x = 33{,}9$ kN, $A_y = 73{,}9$ kN
9.23. $\bar{x} = 0{,}4$ pés
9.25. $\bar{x} = 0{,}45$ m
9.26. $\bar{y} = 0{,}45$ m
9.27. $\bar{x} = 1{,}08$ pol
9.29. $\bar{x} = 1{,}61$ pol
9.30. $\bar{y} = 1{,}33$ pol
9.31. $\bar{r} = 0{,}833\, a$
9.33. $\bar{x} = \bar{y} = 0$, $\bar{z} = \frac{4}{3}$ m
9.34. $\bar{z} = \frac{3}{8}a$
9.35. $\bar{z} = \frac{5}{6}h$

9.37. $\bar{x} = 0{,}4a$
9.38. $\bar{z} = 2{,}50$ pés
9.39. $\bar{y} = 2{,}67$ m
9.41. $\bar{z} = \dfrac{R^2 + 3r^2 + 2rR}{4(R^2 + r^2 + rR)}h$
9.42. $m = \dfrac{\pi k r^4}{4}$, $\bar{z} = \dfrac{8}{15}r$
9.43. $\bar{z} = \dfrac{c}{4}$
9.45. $\bar{x} = 1{,}30$ m, $\bar{y} = 2{,}30$ m
9.46. $\bar{x} = 34{,}4$ mm, $\bar{y} = 85{,}8$ mm
9.47. $\bar{x} = 179$ mm
9.49. $\bar{x} = 0$, $\bar{y} = 5{,}14$ pol
9.50. $\bar{x} = 0$, $\bar{y} = 58{,}3$ mm
9.51. $\bar{x} = 1{,}60$ pol, $\bar{y} = 7{,}04$ pés, $A_x = 0$, $A_y = 149$ lb, $M_A = 502$ lb · pés
9.53. $\bar{y} = 85{,}9$ mm
9.54. $\bar{x} = 2{,}22$ m, $\bar{y} = 1{,}41$ m
9.55. $\bar{y} = 53{,}0$ mm
9.57. $\bar{y} = 154$ mm
9.58. $\bar{x} = 4{,}62$ pol, $\bar{y} = 1{,}00$ pol
9.59. $\bar{x} = 3{,}00$ pol, $\bar{y} = 2{,}00$ pol
9.61. $\bar{y} = 11{,}9$ pol
9.62. $\bar{x} = \dfrac{\frac{2}{3}r\,\text{sen}^3\,\alpha}{\alpha - \frac{\text{sen}\,2\alpha}{2}}$
9.63. $\bar{y} = 2{,}00$ pol
9.65. $\bar{x} = 77{,}2$ mm, $\bar{y} = 31{,}7$ mm
9.66. $\bar{y} = 135$ mm
9.67. $\bar{y} = 10{,}2$ pol
9.69. $h = 323$ mm
9.70. $\bar{z} = 128$ mm
9.71. $\bar{x} = -1{,}14$ pol, $\bar{y} = 1{,}71$ pol, $\bar{z} = -0{,}857$ pol
9.73. $\bar{x} = 4{,}74$ pol, $\bar{y} = 2{,}99$ pol
9.74. $\bar{x} = 2{,}81$ pés $\bar{y} = 1{,}73$ pé, $N_B = 72{,}1$ lb, $N_A = 86{,}9$ lb
9.75. $\bar{x} = 19{,}0$ pés $\bar{y} = 11{,}0$ pés
9.77. $\bar{z} = 0{,}70$ pés
9.78. $h = 2{,}00$ pés
9.79. $\bar{z} = 101$ mm
9.81. $\bar{z} = 1{,}625$ pol
9.82. $\bar{z} = 58{,}1$ mm
9.83. $\bar{x} = 8{,}22$ pol
9.85. $A = 118$ pol^2
9.86. $A = 3{,}33$ pés^2, $\bar{y} = 1{,}2$ pé, $V = 25{,}1$ pés^3
9.87. $m = 138$ kg
9.89. $V = 3{,}49$ m^3
9.90. $V = 4{,}25(10^6)$ mm^3
9.91. $R = 29{,}3$ kip
9.93. $V = 1{,}40(10^3)$ pol^3
9.94. $W = 3{,}12(10^6)$ lb
9.95. $A = 3{,}56(10^3)$ pés^2
9.97. $W = 84{,}7$ kip
9.98. Quantidade de galões = 2,75 gal.
9.99. $V = 207$ m^3, $A = 188$ m^2
9.101. $V = 28{,}7$ pol^3
9.102. $W = 0{,}377$ lb
9.103. $h = 106$ mm
9.105. $A = 119(10^3)$ mm^2
9.106. $F = 1{,}41$ MN, $h = 4$ m
9.107. $F_{R_A} = 157$ kN, $F_{R_A} = 235$ kN, $d = 4{,}22$ m
9.109. $d = 2{,}68$ m
9.110. $F_{AB} = 486$ kip
9.111. $F = 391$ kN/m
9.113. $F_{R_C} = 260$ kip, $F_{R_A} = 487{,}5$ kip
9.114. $A_y = 2{,}51$ MN, $B_x = 2{,}20$ MN, $B_y = 859$ kN
9.115. $F_R = 17{,}2$ kip, $d = 5{,}22$ pés, $F_R = 18{,}8$ kip
9.117. $F_R = 40{,}0$ kip, $\bar{z} = 8{,}00$ pés
9.118. $F_{R_z} = 196$ lb, $F_{R_A} = 125$ lb
9.119. $F = 678$ lb, $\bar{x} = 0{,}948$ pé $\bar{y} = 1{,}50$ pé
9.121. $F_R = 4{,}00$ kip, $\bar{y} = -6{,}49$ pés
9.122. $\bar{x} = 0$, $\bar{y} = 2{,}40$ m, $F_R = 42{,}7$ kN, $B_y = C_y = 12{,}8$ kN, $A_y = 17{,}1$ kN
9.123. $F_R = 6{,}93$ kN, $\bar{y} = -0{,}125$ m
9.125. $A = 1{,}25$ m^2
9.126. $\bar{y} = 87{,}5$ mm
9.127. $\bar{x} = \bar{y} = 0$, $\bar{z} = \dfrac{2}{3}a$
9.129. $\theta = 37{,}8°$
9.130. $\bar{y} = 0{,}600$ pol
9.131. $\bar{x} = 1{,}22$ pé $\bar{y} = 0{,}778$ pé, $\bar{z} = 0{,}778$ pé, $M_{A_x} = 16{,}0$ lb · pés $M_{A_y} = 57{,}1$ lb · pés, $M_{A_z} = 0$, $A_x = 0$, $A_y = 0$, $A_z = 20{,}6$ lb
9.133. $F_R = 24{,}0$ kN, $\bar{x} = 2{,}00$ m, $\bar{y} = 1{,}33$ m
9.134. $F_R = 7{,}62$ kN, $\bar{x} = 2{,}74$ m, $\bar{y} = 3{,}00$ m

Capítulo 10

10.1. $I_x = 39{,}0$ m^4
10.2. $I_y = 8{,}53$ m^4
10.3. $I_x = 23{,}8$ pés^4,
10.5. $I_y = 1{,}07$ pé^4
10.6. $I_x = \dfrac{2}{15}bh^3$
10.7. $I_x = 1{,}54$ pol^4
10.9. $I_x = \dfrac{2}{7}bh^3$
10.10. $I_y = \dfrac{2}{15}hb^3$
10.11. $I_x = 10{,}7$ pol^4
10.13. $I_y = 2{,}44$ m^4
10.14. $I_x = 0{,}571$ pol^4
10.15. $I_y = 1{,}07$ pol^4

10.17. $I_x = 0{,}176\ \text{m}^4$
10.18. $I_x = 9{,}05\ \text{pol}^4$
10.19. $I_y = 30{,}9\ \text{pol}^4$
10.21. $I_y = 10{,}7\ \text{pol}^4$
10.22. $I_x = 3{,}20\ \text{m}^4$
10.23. $I_y = 0{,}628\ \text{m}^4$
10.25. $A = 2{,}44\ \text{pol}^2$
10.26. $A = 11{,}1(10^3)\ \text{mm}^2$
10.27. $I_x = 3{,}35(10^3)\ \text{pol}^4$
10.29. $\overline{I}_{x'} = 162(10^6)\ \text{mm}^4$
10.30. $\overline{y} = 2{,}00\ \text{pol}$, $\overline{I}_{x'} = 64{,}0\ \text{pol}^4$
10.31. $\overline{x} = 3{,}00\ \text{pol}$, $\overline{I}_{y'} = 136\ \text{pol}^4$
10.33. $I_{x'} = 49{,}5(10^6)\ \text{mm}^4$
10.34. $I_x = 1{,}21(10^3)\ \text{pol}^4$, $I_y = 364{,}8\ \text{pol}^4$
10.35. $I_{x'} = 95{,}9(10^6)\ \text{mm}^4$
10.37. $\overline{y} = 80{,}7\ \text{mm}$, $\overline{I}_{x'} = 67{,}6(10^6)\ \text{mm}^4$
10.38. $\overline{x} = 61{,}6\ \text{mm}$, $\overline{I}_{y'} = 41{,}2(10^6)\ \text{mm}^4$
10.39. $\overline{y} = 0{,}181\ \text{m}$, $I_{x'} = 40{,}23(10^{-3})\ \text{m}^4$
10.41. $\overline{y} = 22{,}5\ \text{mm}$, $I_{x'} = 34{,}4(10^6)\ \text{mm}^4$
10.42. $I_{y'} = 122(10^6)\ \text{mm}^4$
10.43. $I_x = 648\ \text{pol}^4$
10.45. $\overline{y} = 2\ \text{pol}$, $\overline{I}_{x'} = 128\ \text{pol}^4$
10.46. $I_x = I_y = 503\ \text{pol}^4$
10.47. $\overline{I}_{x'} = \frac{1}{12}a^3b\ \text{sen}^3\,\theta$
10.49. $\overline{y} = 53{,}0\ \text{mm}$, $I_{x'} = 3{,}67(10^6)\ \text{mm}^4$
10.50. $I_{x'} = 30{,}2(10^6)\ \text{mm}^4$
10.51. $\overline{y} = 91{,}7\ \text{mm}$, $I_{x'} = 216(10^6)\ \text{mm}^4$
10.53. $\overline{I}_{x'} = \frac{1}{36}bh^3$, $\overline{I}_{y'} = \frac{1}{36}hb(b^2 - ab + a^2)$
10.54. $I_{xy} = 0$
10.55. $I_{xy} = 0{,}667\ \text{pol}^4$
10.57. $I_{xy} = \frac{1}{6}a^2b^2$
10.58. $I_{xy} = 48\ \text{pol}^4$
10.59. $I_{xy} = 2{,}00\ \text{pol}^4$
10.61. $I_{xy} = \frac{3}{16}b^2h^2$
10.62. $I_{xy} = \frac{a^4}{280}$
10.63. $I_{xy} = \frac{a^2b^2}{4(n+1)}$
10.65. $I_{xy} = 0{,}511\ \text{m}^4$
10.66. $I_{xy} = \frac{1}{6}\ell^3 t\ \text{sen}\ 2\theta$
10.67. $I_{xy} = -28{,}1(10^3)\ \text{mm}^4$
10.69. $I_{xy} = 36{,}0\ \text{pol}^4$
10.70. $I_{xy} = \frac{a^2c\ \text{sen}^2\,\theta}{12}(4a\ \text{cosec}\,\theta + 3c)$
10.71. $I_{xy} = 98{,}4(10^6)\ \text{mm}^4$
10.73. $I_{xy} = 0{,}74\ \text{pol}^4$
10.74. $I_{uv} = 135(10)^6\ \text{mm}^4$
10.75. $I_u = 114(10^6)\ \text{mm}^4$, $I_v = 56{,}5(10^6)\ \text{mm}^4$
10.77. $I_u = 15{,}75\ \text{pol}^4$, $I_v = 25{,}75\ \text{pol}^4$
10.78. $\theta = -22{,}5°$, $I_{\text{máx}} = 250\ \text{pol}^4$, $I_{\text{mín}} = 20{,}4\ \text{pol}^4$
10.79. $I_u = 3{,}47(10^3)\ \text{pol}^4$, $I_v = 3{,}47(10^3)\ \text{pol}^4$, $I_{uv} = 2{,}05(10^3)\ \text{pol}^4$
10.81. $I_{\text{máx}} = 64{,}1\ \text{pol}^4$, $I_{\text{mín}} = 5{,}33\ \text{pol}^4$
10.82. $I_{\text{máx}} = 4{,}92(10^6)\ \text{mm}^4$, $I_{\text{mín}} = 1{,}36(10^6)\ \text{mm}^4$
10.83. $I_{\text{máx}} = 1{,}74(10^3)\ \text{pol}^4$, $I_{\text{mín}} = 435\ \text{pol}^4$
10.85. $I_{\text{máx}} = 250\ \text{pol}^4$, $I_{\text{mín}} = 20{,}4\ \text{pol}^4$
10.86. $I_{\text{máx}} = 64{,}1\ \text{pol}^4$, $I_{\text{mín}} = 5{,}33\ \text{pol}^4$
10.87. $I_{\text{máx}} = 4{,}92(10^6)\ \text{mm}^4$, $I_{\text{mín}} = 1{,}36(10^6)\ \text{mm}^4$
10.89. $I_{\text{máx}} = 1{,}74(10^3)\ \text{pol}^4$, $I_{\text{mín}} = 435\ \text{pol}^4$
10.90. $I_y = \frac{1}{3}ml^2$
10.91. $I_z = mR^2$
10.93. $I_x = \frac{2}{5}mr^2$
10.94. $k_x = 57{,}7\ \text{mm}$
10.95. $I_x = \frac{2}{5}mb^2$
10.97. $I_x = \frac{2}{5}mb^2$
10.98. $I_y = \frac{m}{6}(a^2 + h^2)$
10.99. $I_y = 2{,}25\ \text{slug} \cdot \text{pés}^2$
10.101. $I_z = 1{,}53\ \text{kg} \cdot \text{m}^2$
10.102. $I_G = 118\ \text{slug} \cdot \text{pés}^2$
10.103. $I_O = 293\ \text{slug} \cdot \text{pés}^2$
10.105. $I = 2{,}17\ \text{slug} \cdot \text{pés}^2$
10.106. $I_z = 34{,}2\ \text{kg} \cdot \text{m}^2$
10.107. $I_A = 1{,}58\ \text{slug} \cdot \text{pés}^2$
10.109. $I_x = 3{,}25 \times 10^{-3}\ \text{kg} \cdot \text{m}^2$
10.110. $I_{x'} = 7{,}20 \times 10^{-3}\ \text{kg} \cdot \text{m}^2$
10.111. $\overline{y} = 203\ \text{mm}$, $I_G = 0{,}230\ \text{kg} \cdot \text{m}^2$
10.113. $I_y = 0{,}0954d^4$
10.114. $I_y = 0{,}187d^4$
10.115. $I_x = \frac{93}{70}mb^2$
10.117. $I_u = 5{,}09(10^6)\ \text{mm}^4$, $I_v = 5{,}09(10^6)\ \text{mm}^4$, $I_{uv} = 0$
10.118. $I_y = 2{,}13\ \text{pés}^4$
10.119. $I_x = 0{,}610\ \text{pé}^4$
10.121. a) $I_x = \frac{bh^3}{12}$, b) $\overline{I}_{x'} = \frac{bh^3}{36}$
10.122. $I_{xy} = 0{,}1875\ \text{m}^4$

Capítulo 11

11.1. $F_{AC} = 7{,}32$ lb

11.2. $\theta = 0°$, $\theta = 73{,}1°$

11.3. $F = 24{,}5$ N

11.5. $k = 1{,}05$ kN/m

11.6. $F = 512$ N

11.7. $F = \dfrac{500\sqrt{0{,}04\cos^2\theta + 0{,}6}}{(0{,}2\cos\theta + \sqrt{0{,}04\cos^2\theta + 0{,}6})\,\text{sen}\,\theta}$

11.9. $\theta = 13{,}9°$, $\theta = 90°$

11.10. $\theta = 0°$, $\theta = 36{,}9°$

11.11. $M = 52{,}0$ lb · pé

11.13. $P = \dfrac{W}{2}\,\text{cotg}\,\theta$

11.14. $\theta = 16{,}6°$, $\theta = 35{,}8°$

11.15. $\theta = 15{,}5°$, $\theta = 85{,}4°$

11.17. $F = 4{,}62$ kN

11.18. $k = 10{,}8$ lb/pé

11.19. $F = 2P\,\text{cotg}\,\theta$

11.21. $M = 42{,}5$ N · m

11.22. $F = 259$ lb

11.23. $\theta = \cos^{-1}\left(\dfrac{a}{2L}\right)^{\frac{1}{3}}$

11.25. $m = 100$ kg

11.26. Instabilidade em $x = 0$
Estabilidade em $x = 0{,}167$ m

11.27. Instabilidade em $\theta = 34{,}6°$,
Estabilidade em $\theta = 145°$

11.29. (0, 0), estabilidade

11.30. $\theta = 0°$, $\theta = \cos^{-1}\left(\dfrac{W}{2KL}\right)$,
o equilíbrio indiferente ocorre quando $W = 2kL$

11.31. $k = 2{,}81$ lb/pé

11.33. $\theta = 23{,}2°$, instável

11.34. $k = 100$ lb/pé

11.37. $h = 0$

11.38. $\theta = \text{sen}^{-1}\left(\dfrac{4W}{Ka}\right)$, $\theta = 90°$

11.39. $m = 5{,}29$ kg

11.41. $d = 87{,}9$ mm

11.42. $b < 2r$

11.43. $d = \dfrac{h}{3}$

11.46. $P = 5{,}28$ lb

11.47. $\theta = 37{,}8°$, instável

11.49. Instabilidade em $\theta = 90°$,
Estabilidade em $\theta = 9{,}47°$

11.50. $\theta = 90°$, $\theta = 30°$

11.51. Instável em $\theta = 90°$,
Estável em $\theta = 30°$