

Answers to Problems

CHAPTER 2

- 2.1** 1391 N \nearrow 47.8°.
2.2 906 lb \nearrow 26.6°.
2.3 20.1 kN \nearrow 21.2°.
2.4 8.03 kips \nearrow 3.8°.
2.5 (a) 392 lb. (b) 346 lb.
2.7 (a) 3660 N. (b) 3730 N.
2.9 (a) 37.1°. (b) 73.2 N.
2.10 $P = 72.1$ N; $\alpha = 44.7^\circ$.
2.11 2600 N \searrow 53.5°.
2.12 414 lb \searrow 72.0°.
2.13 139.1 lb \nearrow 67.0°.
2.14 8.03 kips \nearrow 3.8°.
2.16 (800 N) +640 N, +480 N; (424 N) -224 N, -360 N;
 (408 N) +192.0 N, -360 N.
2.17 (29 lb) +21.0 lb, +20.0 lb; (50 lb) -14.00 lb, +48.0 lb;
 (51 lb) +24.0 lb, -45.0 lb.
2.18 (40 lb) +20.0 lb, -34.6 lb; (50 lb) -38.3 lb, -32.1 lb;
 (60 lb) +54.4 lb, +25.4 lb.
2.19 (80 N) +61.3 N, +51.4 N; (120 N) +41.0 N, +112.8 N;
 (150 N) -122.9 N, 86.0 N.
2.20 (a) 523 lb. (b) 428 lb.
2.23 (a) 2.22 kN. (b) 2.10 kN.
2.24 654 N \searrow 21.5°.
2.25 38.6 lb \nearrow 36.6°.
2.26 54.9 lb \searrow 48.9°.
2.27 251 N \searrow 85.3°.
2.29 (a) 177.9 lb. (b) 410 lb.
2.31 (a) 26.5 N. (b) 623 N.
2.32 (a) 5.22 kN. (b) 3.45 kN.
2.33 (a) 352 lb. (b) 261 lb.
2.34 (a) 716 N. (b) 381 N.
2.35 (a) 500 lb. (b) 544 lb.
2.36 (a) 305 N. (b) 514 N.
2.38 $T_A = 231$ lb; $T_B = 577$ lb.
2.40 $F_A = 1303$ lb; $F_B = 420$ lb.
2.41 (a) 269 lb. (b) 37.0 lb.
2.43 (a) $\alpha = 35.0^\circ$; $T_{AC} = 4.91$ kN; $T_{BC} = 3.44$ kN.
 (b) $\alpha = 55.0^\circ$; $T_{AC} = T_{BC} = 3.66$ kN.
2.44 (a) 784 N. (b) 71.0°.
2.45 (a) 1081 N. (b) 82.5°.
2.47 $30.0 \text{ lb} \leq Q \leq 69.3 \text{ lb}$.
2.48 (a) 10.98 lb. (b) 30.0 lb.
2.49 68.6 in.
2.50 (a) 2450 N. (b) 2220 N.
2.51 (a) 300 lb. (b) 300 lb. (c) 200 lb. (d) 200 lb. (e) 150.0 lb.
2.54 (a) 1293 N. (b) 2220 N.
2.55 (a) 1048 N. (b) 608 N.
2.56 (a) +278 N, +383 N, +160.7 N. (b) 56.2° , 40.0° , 71.3° .
2.57 (a) -115.6 N, +752 N, +248 N. (b) 98.3° , 20.0° , 71.9° .
2.58 (a) +56.4 lb; -103.9 lb; -20.5 lb. (b) 62.0° ; 150.0° ; 99.8° .
2.59 (a) +37.1 lb; -68.8 lb; +33.4 lb. (b) 64.1° ; 144.0° ; 66.8° .
2.60 (a) -175.8 N; -257 N; +251 N. (b) 116.1° ; 130.0° ; 51.1° .
2.63 $F = 900$ N; $\theta_x = 73.2^\circ$, $\theta_y = 110.8^\circ$, $\theta_z = 27.3^\circ$.
2.64 (a) 140.3° . (b) $F_x = 79.9$ lb, $F_z = 120.1$ lb; $F = 226$ lb.
2.65 (a) 118.2° . (b) $F_x = 36.0$ lb, $F_y = -90.0$ lb; $F = 110.0$ lb.
2.66 (a) 114.4° . (b) $F_y = 294$ lb, $F_z = 855$ lb; $F = 1209$ lb.
2.67 (a) $F_x = 507$ N, $F_y = 919$ N, $F_z = 582$ N. (b) 61.0° .
2.68 -240 N, +444 N, -192.0 N.
2.71 -0.820 kips, 0.978 kips, -0.789 kips.
2.72 515 N; $\theta_x = 70.2^\circ$, $\theta_y = 27.6^\circ$, $\theta_z = 71.5^\circ$.
2.73 515 N; $\theta_x = 79.8^\circ$, $\theta_y = 33.4^\circ$, $\theta_z = 58.6^\circ$.
2.75 913 lb; $\theta_x = 50.6^\circ$, $\theta_y = 117.6^\circ$, $\theta_z = 51.8^\circ$.
2.77 1171 N; $\theta_x = 89.5^\circ$, $\theta_y = 36.2^\circ$, $\theta_z = 126.2^\circ$.
2.78 130.0 lb.
2.79 137.0 lb.
2.80 13.98 kN.
2.81 9.71 kN.
2.82 $T_{AB} = 201$ N; $T_{AC} = 372$ N; $T_{AD} = 416$ N.
2.83 3380 lb.
2.84 $T_{AB} = T_{AC} = 3.35$ lb; $T_{AD} = 5.80$ lb.
2.86 $T_{DA} = 119.7$ lb; $T_{DB} = 98.4$ lb; $T_{DC} = 98.4$ lb.
2.87 $T_{DA} = 14.42$ lb; $T_{DB} = T_{DC} = 13.00$ lb.
2.89 768 N.
2.90 $T_{AB} = 30.8$ lb; $T_{AC} = 62.5$ lb.
2.91 $T_{AB} = 81.3$ lb; $T_{AC} = 22.2$ lb.
2.92 960 N.
2.93 $0 \leq Q < 300$ N.
2.95 $W = 470$ N; $Q = 37.0$ N.
2.97 (a) 305 lb. (b) $T_{BAC} = 117.0$ lb; $T_{AD} = 40.9$ lb.
2.98 378 N.
2.99 $T_{AB} = 65.6$ lb; $T_{AC} = 55.1$ lb.
2.100 (a) 125.0 lb. (b) 45.0 lb.
2.102 (a) 1155 N. (b) 1012 N.
2.104 21.8 kN \searrow 73.4°.
2.105 (102 lb) -48.0 lb, 90.0 lb; (106 lb) 56.0 lb, 90.0 lb; (200 lb)
 -160.0 lb, -120.0 lb.
2.107 203 lb \nearrow 8.46°.
2.108 (a) 1244 lb. (b) 115.4 lb.
2.110 $27.4^\circ \leq \alpha \leq 222.6^\circ$.
2.112 1031 N \uparrow .
2.113 956 N \uparrow .
2.115 3090 lb.

CHAPTER 3

- 3.1** 186.6 lb-in. \curvearrowright .
3.2 8.97 lb \searrow 19.98°.
3.3 (a) 20.5 N·m \curvearrowright . (b) 68.4 mm.
3.5 (a) 41.7 N·m \curvearrowright . (b) 147.4 N \nearrow 45.0°.
3.6 (a) 41.7 N·m \curvearrowright . (b) 334 N. (c) 176.8 N \nearrow 58.0°.
3.7 116.2 lb-ft.
3.9 1.120 kip-in. \curvearrowright .
3.11 (a) 292 N·m \curvearrowright . (b) 292 N·m \curvearrowright .
3.12 2340 N.

- 3.14** (a) $-58\mathbf{i} + 4\mathbf{j} + 32\mathbf{k}$. (b) $6\mathbf{i} - 4\mathbf{k}$. (c) $-30\mathbf{i} + 12\mathbf{j}$.
3.15 $-(25.4 \text{ lb}\cdot\text{ft})\mathbf{i} - (12.60 \text{ lb}\cdot\text{ft})\mathbf{j} - (12.60 \text{ lb}\cdot\text{ft})\mathbf{k}$.
3.16 (a) $(28.8 \text{ N}\cdot\text{m})\mathbf{i} + (16.20 \text{ N}\cdot\text{m})\mathbf{j} - (28.8 \text{ N}\cdot\text{m})\mathbf{k}$.
 (b) $-(28.8 \text{ N}\cdot\text{m})\mathbf{i} - (16.20 \text{ N}\cdot\text{m})\mathbf{j} + (28.8 \text{ N}\cdot\text{m})\mathbf{k}$.
3.17 $(2400 \text{ lb}\cdot\text{ft})\mathbf{j} + (1440 \text{ lb}\cdot\text{ft})\mathbf{k}$.
3.18 $-(153.0 \text{ lb}\cdot\text{ft})\mathbf{i} + (63.0 \text{ lb}\cdot\text{ft})\mathbf{j} + (215 \text{ lb}\cdot\text{ft})\mathbf{k}$.
3.19 $(3080 \text{ N}\cdot\text{m})\mathbf{i} - (2070 \text{ N}\cdot\text{m})\mathbf{k}$.
3.20 $(492 \text{ lb}\cdot\text{ft})\mathbf{i} + (144.0 \text{ lb}\cdot\text{ft})\mathbf{j} - (372 \text{ lb}\cdot\text{ft})\mathbf{k}$.
3.23 7.37 ft.
3.24 70.8 mm.
3.25 $\mathbf{P}\cdot\mathbf{Q} = +1$; $\mathbf{P}\cdot\mathbf{S} = -11$; $\mathbf{Q}\cdot\mathbf{S} = +10$.
3.27 (a) 59.0° . (b) 648 N.
3.28 (a) 70.5° . (b) 135.0 N.
3.29 38.7° .
3.31 (a) 26.8° . (b) 26.8° .
3.33 (a) 67.0. (b) 111.0.
3.34 2.
3.35 $M_x = 0$; $M_y = -162.0 \text{ N}\cdot\text{m}$; $M_z = 270 \text{ N}\cdot\text{m}$.
3.37 283 lb.
3.39 1.252 m.
3.40 1.256 m.
3.41 $\phi = 24.6^\circ$; $d = 34.6 \text{ in}$.
3.42 $-227 \text{ lb}\cdot\text{ft}$.
3.43 1359 lb-in.
3.44 $-2350 \text{ lb}\cdot\text{in}$.
3.46 $-111.0 \text{ N}\cdot\text{m}$.
3.48 910 lb.
3.49 (a) $12.39 \text{ N}\cdot\text{m}$ \curvearrowright . (b) $12.39 \text{ N}\cdot\text{m}$ \curvearrowright . (c) $12.39 \text{ N}\cdot\text{m}$ \curvearrowright .
3.50 (a) $336 \text{ lb}\cdot\text{in}$ \curvearrowright . (b) 28.0 in. (c) 54.0° .
3.51 $16.39 \text{ N}\cdot\text{m}$ \curvearrowright .
3.52 (a) 26.7 N. (b) 50.0 N. (c) 23.5 N.
3.53 (a) $1170 \text{ lb}\cdot\text{in}$ \curvearrowright . (b) A and D, 53.1° \curvearrowright , or B and C \curvearrowleft 53.1° . (c) 70.9 lb.
3.54 1.125 in.
3.56 $M = 15.30 \text{ lb}\cdot\text{ft}$; $\theta_x = 78.7^\circ$; $\theta_y = 90.0^\circ$; $\theta_z = 11.30^\circ$.
3.57 (a) $M = 13.63 \text{ N}\cdot\text{m}$; $\theta_x = 27.8^\circ$; $\theta_y = 62.2^\circ$; $\theta_z = 90.0^\circ$.
 (b) 18.17 N \curvearrowleft 62.2° at B; 18.17 N \curvearrowright 62.2° at C.
3.58 $8.78 \text{ N}\cdot\text{m}$; $\theta_x = 84.8^\circ$; $\theta_y = 43.6^\circ$; $\theta_z = 133.1^\circ$.
3.59 $M = 2150 \text{ lb}\cdot\text{ft}$; $\theta_x = 113.0^\circ$; $\theta_y = 92.7^\circ$; $\theta_z = 23.2^\circ$.
3.61 (a) $\mathbf{F} = 30.0 \text{ lb}$ \downarrow ; $\mathbf{M}_B = 150.0 \text{ lb}\cdot\text{in}$ \curvearrowright .
 (b) $\mathbf{F}_B = 50.0 \text{ lb}$ \leftarrow ; $\mathbf{F}_C = 50.0 \text{ lb}$ \rightarrow .
3.63 (a) $\mathbf{F}_B = 250 \text{ N}$ \curvearrowleft 25.0° ; $\mathbf{M}_B = 57.5 \text{ N}\cdot\text{m}$ \curvearrowright .
 (b) $\mathbf{F}_A = 375 \text{ N}$ \curvearrowright 25.0° ; $\mathbf{F}_B = 625 \text{ N}$ \curvearrowleft 25.0° .
3.65 $\mathbf{F}_A = 389 \text{ N}$ \curvearrowleft 60.0° ; $\mathbf{F}_C = 651 \text{ N}$ \curvearrowleft 60.0° .
3.66 (a) $\mathbf{P} = 60.0 \text{ lb}$ \curvearrowright 50.0° ; 3.24 in. from A.
 (b) $\mathbf{P} = 60.0 \text{ lb}$ \curvearrowright 50.0° ; 3.87 in. below A.
3.67 $\mathbf{F} = -(250 \text{ kN})\mathbf{j}$; $\mathbf{M} = (15.00 \text{ kN}\cdot\text{m})\mathbf{i} + (7.50 \text{ kN}\cdot\text{m})\mathbf{k}$.
3.68 $\mathbf{F} = -(128.0 \text{ lb})\mathbf{i} - (256 \text{ lb})\mathbf{j} + (32.0 \text{ lb})\mathbf{k}$;
 $\mathbf{M} = -(4.10 \text{ kip}\cdot\text{ft})\mathbf{i} + (16.38 \text{ kip}\cdot\text{ft})\mathbf{k}$.
3.71 $\mathbf{F} = -(2.40 \text{ kips})\mathbf{j} - (1.000 \text{ kips})\mathbf{k}$; $\mathbf{M} = -(12.00 \text{ kip}\cdot\text{in.})\mathbf{i}$
 $+ (6.00 \text{ kip}\cdot\text{in.})\mathbf{j} - (14.40 \text{ kip}\cdot\text{in.})\mathbf{k}$.
3.72 $\mathbf{F} = -(28.5 \text{ N})\mathbf{j} + (106.3 \text{ N})\mathbf{k}$; $\mathbf{M}_O = (12.35 \text{ N}\cdot\text{m})\mathbf{i}$
 $- (19.16 \text{ N}\cdot\text{m})\mathbf{j} - (5.13 \text{ N}\cdot\text{m})\mathbf{k}$.
3.73 (a) $\mathbf{R}_a = 600 \text{ N}$ \downarrow ; $\mathbf{M}_a = 1000 \text{ N}\cdot\text{m}$ \curvearrowright ; $\mathbf{R}_b = 600 \text{ N}$ \downarrow ;
 $\mathbf{M}_b = 900 \text{ N}\cdot\text{m}$ \curvearrowright ; $\mathbf{R}_c = 600 \text{ N}$ \downarrow ; $\mathbf{M}_c = 900 \text{ N}\cdot\text{m}$ \curvearrowright ;
 $\mathbf{R}_d = 400 \text{ N}$ \uparrow ; $\mathbf{M}_d = 900 \text{ N}\cdot\text{m}$ \curvearrowright ; $\mathbf{R}_e = 600 \text{ N}$ \downarrow ;
 $\mathbf{M}_e = 200 \text{ N}\cdot\text{m}$ \curvearrowright ; $\mathbf{R}_f = 600 \text{ N}$ \downarrow ; $\mathbf{M}_f = 800 \text{ N}\cdot\text{m}$ \curvearrowright ;
 $\mathbf{R}_g = 1000 \text{ N}$ \downarrow ; $\mathbf{M}_g = 1000 \text{ N}\cdot\text{m}$ \curvearrowright ; $\mathbf{R}_h = 600 \text{ N}$ \downarrow ;
 $\mathbf{M}_h = 900 \text{ N}\cdot\text{m}$ \curvearrowright . (b) (c) and (h).

- 3.74** Loading f .
3.75 (a) $\mathbf{R} = 600 \text{ N}$ \downarrow ; 1.500 m. (b) $\mathbf{R} = 400 \text{ N}$ \uparrow ; 2.25 m.
 (c) $\mathbf{R} = 600 \text{ N}$ \downarrow ; 0.333 m.
3.76 (a) 2.00 ft to the right of C. (b) 2.31 ft to the right of C.
3.78 Force-couple system at corner D.
3.80 $\mathbf{R} = 185.2 \text{ lb}$ \curvearrowright 11.84° ; 23.3 in. to the left of the vertical
 centerline (y-axis) of the motor.
3.81 44.7 lb \curvearrowleft 26.6° ; 10.61 in. to the left of C; 5.30 in. below C.
3.82 72.4 lb \curvearrowright 81.9° ; 206 lb-ft.
3.83 (a) 0.365 m above G. (b) 0.227 m to the right of G.
3.84 (a) 0.299 m above G. (b) 0.259 m to the right of G.
3.85 $\mathbf{R}_A = (8.40 \text{ lb})\mathbf{i} - (19.20 \text{ lb})\mathbf{j} - (3.20 \text{ lb})\mathbf{k}$;
 $\mathbf{M}_A = (71.6 \text{ lb}\cdot\text{ft})\mathbf{i} + (56.8 \text{ lb}\cdot\text{ft})\mathbf{j} - (65.2 \text{ lb}\cdot\text{ft})\mathbf{k}$.
3.87 $\mathbf{R} = (420 \text{ N})\mathbf{j} - (339 \text{ N})\mathbf{k}$;
 $\mathbf{M} = (1.125 \text{ N}\cdot\text{m})\mathbf{i} + (163.9 \text{ N}\cdot\text{m})\mathbf{j} - (109.9 \text{ N}\cdot\text{m})\mathbf{k}$.
3.89 (a) 60.0° . (b) $(20 \text{ lb})\mathbf{i} - (34.6 \text{ lb})\mathbf{j}$; $(520 \text{ lb}\cdot\text{in.})\mathbf{i}$.
3.90 (a) Neither loosen nor tighten. (b) Tighten.
3.91 $\mathbf{R} = -(420 \text{ N})\mathbf{i} - (50 \text{ N})\mathbf{j} - (250 \text{ N})\mathbf{k}$;
 $\mathbf{M} = (30.8 \text{ N}\cdot\text{m})\mathbf{j} - (22.0 \text{ N}\cdot\text{m})\mathbf{k}$.
3.92 405 lb; 12.60 ft to the right of AB and 2.94 ft below BC.
3.94 $\mathbf{R} = 325 \text{ kN}$, $x = -0.923 \text{ m}$; $z = -0.615 \text{ m}$.
3.96 $x = 2.32 \text{ m}$; $z = 1.165 \text{ m}$.
3.97 (a) $800 \text{ lb}\cdot\text{in}$ \curvearrowright ; (b) 51.3 lb; (c) 44.4 lb \curvearrowright 20° .
3.99 $M_x = 78.9 \text{ N}\cdot\text{m}$, $M_y = 13.15 \text{ kN}\cdot\text{m}$, $M_z = -9.86 \text{ kN}\cdot\text{m}$.
3.101 23.0 N-m.
3.102 $(0.227 \text{ lb})\mathbf{i} + (0.1057 \text{ lb})\mathbf{k}$; 63.6 in. to the right of B.
3.103 (a) $\mathbf{F} = 500 \text{ N}$ \curvearrowleft 60.0° ; $\mathbf{M} = 86.2 \text{ N}\cdot\text{m}$ \curvearrowright .
 (b) $\mathbf{A} = 689 \text{ N}$ \uparrow ; $\mathbf{B} = 1150 \text{ N}$ \curvearrowleft 77.4° .
3.105 (a) 71.1° . (b) 0.973 lb.
3.106 12.00 in.
3.108 $aP/\sqrt{2}$.

CHAPTER 4

- 4.1** (a) 245 lb \uparrow . (b) 140.0 lb.
4.2 (a) 325 lb \uparrow . (b) 1175 lb \uparrow .
4.3 42.0 N \uparrow .
4.5 $1.250 \text{ kN} \leq Q \leq 27.5 \text{ kN}$.
4.6 $1.250 \text{ kN} \leq Q \leq 10.25 \text{ kN}$.
4.7 $2.00 \text{ in.} \leq a \leq 10.00 \text{ in.}$
4.9 (a) $T = (W \cos \theta)/(2 \cos(\theta/2))$. (b) 11.74 lb.
4.10 (a) 125.0 lb. (b) 261 lb \curvearrowright 69.8° .
4.12 (a) 400 N. (b) 458 N \curvearrowright 49.1° .
4.13 (a) $\mathbf{A} = \mathbf{B} = 37.5 \text{ lb}$ \uparrow . (b) $\mathbf{A} = 97.6 \text{ lb}$ \curvearrowright 50.2° ;
 $\mathbf{B} = 62.5 \text{ lb}$ \leftarrow . (c) $\mathbf{A} = 49.8 \text{ lb}$ \curvearrowright 71.2° ; $\mathbf{B} = 32.2 \text{ lb}$ \curvearrowleft 60.0° .
4.15 (a) 1.500 kN. (b) 1.906 kN \curvearrowright 61.8° .
4.16 (a) $\mathbf{A} = 150.0 \text{ N}$ \curvearrowright 30.0° ; $\mathbf{B} = 150.0 \text{ N}$ \curvearrowleft 30.0° .
 (b) $\mathbf{A} = 433 \text{ N}$ \curvearrowleft 12.55° ; $\mathbf{B} = 488 \text{ N}$ \curvearrowleft 30.0° .
4.17 $T_{BE} = 50.0 \text{ lb}$; $\mathbf{A} = 18.75 \text{ lb}$ \rightarrow ; $\mathbf{D} = 18.75 \text{ lb}$ \leftarrow .
4.18 $T = 80.0 \text{ N}$; $\mathbf{A} = 160.0 \text{ N}$ \curvearrowleft 30.0° ; $\mathbf{C} = 160.0 \text{ N}$ \curvearrowleft 30.0° .
4.19 $T = 69.3 \text{ N}$; $\mathbf{A} = 140.0 \text{ N}$ \curvearrowleft 30.0° ; $\mathbf{C} = 180.0 \text{ N}$ \curvearrowleft 30.0° .
4.20 (a) 30.0 lb \curvearrowleft 60.0° . (b) $\mathbf{A} = 20.2 \text{ lb}$ \uparrow ; $\mathbf{F} = 16.21 \text{ lb}$ \downarrow .
4.23 $88.0 \text{ lb.} \leq W \leq 104.0 \text{ lb.}$
4.24 $\mathbf{C} = 28.3 \text{ kN}$ \curvearrowleft 45.0° ; $\mathbf{M}_C = 4.30 \text{ N}\cdot\text{m}$ \curvearrowright .
4.25 (1) Completely constrained; determinate; equilibrium;
 $\mathbf{A} = 120.2 \text{ lb}$ \curvearrowright 56.3° ; $\mathbf{B} = 66.7 \text{ lb}$ \leftarrow .
 (2) Improperly constrained; indeterminate; no equilibrium;
 (3) Partially constrained; determinate; equilibrium;
 $\mathbf{A} = 50.0 \text{ lb}$ \uparrow ; $\mathbf{C} = 50.0 \text{ lb}$ \uparrow .

- (4) Completely constrained; determinate; equilibrium;
 $A = 50.0 \text{ lb } \uparrow$; $B = 83.3 \text{ lb } \nearrow 36.9^\circ$; $C = 66.7 \text{ lb } \rightarrow$.
- (5) Completely constrained; indeterminate; equilibrium;
 $A_y = 50.0 \text{ lb } \uparrow$.
- (6) Completely constrained; indeterminate; equilibrium;
 $A_x = 66.7 \text{ lb } \rightarrow$; $B_x = 66.7 \text{ lb } \leftarrow$; $(A_y + B_y = 100.0 \text{ lb } \uparrow)$.
- (7) Completely constrained; determinate; equilibrium;
 $A = 50.0 \text{ lb } \uparrow$; $C = 50.0 \text{ lb } \uparrow$.
- (8) Improperly constrained; indeterminate; no equilibrium.
- 4.26** (1) Completely constrained; determinate; equilibrium;
 $A = C = 196.2 \text{ N } \uparrow$.
- (2) Completely constrained; determinate; equilibrium;
 $B = 0$; $C = D = 196.2 \text{ N } \uparrow$.
- (3) Completely constrained; indeterminate; equilibrium;
 $A_x = 294 \text{ N } \rightarrow$; $D_x = 294 \text{ N } \leftarrow$.
- (4) Improperly constrained; indeterminate; no equilibrium.
- (5) Partially constrained; determinate; equilibrium;
 $C = D = 196.2 \text{ N } \uparrow$.
- (6) Completely constrained; determinate; equilibrium;
 $B = 294 \text{ N } \rightarrow$; $D = 491 \text{ N } \nearrow 53.1^\circ$.
- (7) Partially constrained; no equilibrium.
- (8) Completely constrained; indeterminate; equilibrium;
 $B = D_y = 196.2 \text{ N } \uparrow$; $(C + D_x = 0)$.
- 4.27** $B = 501 \text{ N } \nearrow 56.3^\circ$; $C = 324 \text{ N } \searrow 31.0^\circ$.
- 4.28** $T = 289 \text{ lb}$; $A = 577 \text{ lb } \nearrow 60.0^\circ$.
- 4.29** $A = 82.5 \text{ lb } \nearrow 14.04^\circ$; $T = 100.0 \text{ lb}$.
- 4.31** $A = 139.0 \text{ N } \nearrow 62.4^\circ$; $T = 69.6 \text{ N}$.
- 4.32** (a) 400 N . (b) $458 \text{ N } \nearrow 49.1^\circ$.
- 4.33** (a) $A = 150.0 \text{ N } \nearrow 30.0^\circ$; $B = 150.0 \text{ N } \searrow 30.0^\circ$.
 (b) $A = 433 \text{ N } \searrow 12.55^\circ$; $B = 488 \text{ N } \searrow 30.0^\circ$.
- 4.34** (a) $P = 24.9 \text{ lb } \nearrow 30.0^\circ$. (b) $P = 15.34 \text{ lb } \nearrow 30.0^\circ$.
- 4.37** $A = 188.8 \text{ lb } \rightarrow$; $D = 327 \text{ N } \searrow 13.24^\circ$.
- 4.38** $C = 270 \text{ lb } \searrow 56.3^\circ$; $D = 167.7 \text{ lb } \searrow 26.6^\circ$.
- 4.40** $\alpha = 73.9^\circ$; $T_A = 4160 \text{ lb}$; $T_B = 2310 \text{ lb}$.
- 4.41** (a) $2P \searrow 60.0^\circ$. (b) $1.239P \searrow 36.2^\circ$.
- 4.42** $\tan \theta = 2 \tan \beta$.
- 4.43** (a) 49.1° . (b) $90.6 \text{ N } \nearrow 60.0^\circ$.
- 4.44** $A = 170.0 \text{ N } \searrow 33.9^\circ$; $C = 160.0 \text{ N } \nearrow 28.1^\circ$.
- 4.45** $A = 170.0 \text{ N } \nearrow 56.1^\circ$; $C = 300 \text{ N } \nearrow 28.1^\circ$.
- 4.47** $A = 163.1 \text{ N } \searrow 55.9^\circ$; $B = 258 \text{ N } \searrow 65.0^\circ$.
- 4.48** $\cos^2 \theta = 1/3 [(R/L)^2 - 1]$.
- 4.50** 32.5° .
- 4.51** $A = (120.0 \text{ N})\mathbf{j} + (133.3 \text{ N})\mathbf{k}$; $D = (60.0 \text{ N})\mathbf{j} + (166.7 \text{ N})\mathbf{k}$.
- 4.52** $A = (125.3 \text{ N})\mathbf{j} + (137.8 \text{ N})\mathbf{k}$; $D = (62.7 \text{ N})\mathbf{j} + (172.2 \text{ N})\mathbf{k}$.
- 4.53** $A = (24.0 \text{ lb})\mathbf{j} - (2.31 \text{ lb})\mathbf{k}$; $B = (16.00 \text{ lb})\mathbf{j} - (9.24 \text{ lb})\mathbf{k}$;
 $C = (11.55 \text{ lb})\mathbf{k}$
- 4.54** (a) 96.0 lb . (b) $A = (2.40 \text{ lb})\mathbf{j}$; $B = (214 \text{ lb})\mathbf{j}$.
- 4.56** (a) 78.5 N . (b) $A = -(27.5 \text{ N})\mathbf{i} + (58.9 \text{ N})\mathbf{j}$;
 $B = (106.0 \text{ N})\mathbf{i} + (58.9 \text{ N})\mathbf{j}$.
- 4.57** $T_A = 30.0 \text{ lb}$; $T_B = 10.00 \text{ lb}$; $T_C = 40.0 \text{ lb}$.
- 4.59** $T_A = 23.5 \text{ N}$; $T_C = 11.77 \text{ N}$; $T_D = 105.9 \text{ N}$.
- 4.61** $T_{DAE} = 520 \text{ lb}$; $T_{BD} = 680 \text{ lb}$; $C = (-120.0 \text{ lb})\mathbf{i} + (120.0 \text{ lb})\mathbf{j}$;
 $+ (1560 \text{ lb})\mathbf{k}$.
- 4.62** $T_{DAE} = 832 \text{ lb}$; $T_{BD} = 1088 \text{ lb}$; $C = (-192.0 \text{ lb})\mathbf{i} + (2496 \text{ lb})\mathbf{k}$.
- 4.63** $T_{BD} = 780 \text{ N}$; $T_{BE} = 390 \text{ N}$; $A = -(195.0 \text{ N})\mathbf{i} + (1170 \text{ N})\mathbf{j}$;
 $+ (130.0 \text{ N})\mathbf{k}$.
- 4.65** $A = -(56.3 \text{ lb})\mathbf{i}$; $B = -(56.2 \text{ lb})\mathbf{i} + (150.0 \text{ lb})\mathbf{j} - (75.0 \text{ lb})\mathbf{k}$;
 $F_{CE} = 202 \text{ lb}$.
- 4.66** (a) 345 N . (b) $A = (114.4 \text{ N})\mathbf{i} + (377 \text{ N})\mathbf{j} + (141.5 \text{ N})\mathbf{k}$;
 $B = (113.2 \text{ N})\mathbf{j} + (185.5 \text{ N})\mathbf{k}$.
- 4.67** (a) 49.5 lb . (b) $A = -(12.00 \text{ lb})\mathbf{i} + (22.5 \text{ lb})\mathbf{j} - (4.00 \text{ lb})\mathbf{k}$;
 $B = (15.00 \text{ lb})\mathbf{j} + (34.0 \text{ lb})\mathbf{k}$.
- 4.70** (a) 462 N . (b) $C = -(336 \text{ N})\mathbf{j} + (467 \text{ N})\mathbf{k}$; $D = (505 \text{ N})\mathbf{j}$;
 $- (66.7 \text{ N})\mathbf{k}$.
- 4.71** $F_{CE} = 202 \text{ lb}$; $M_A = (600 \text{ lb}\cdot\text{ft})\mathbf{i} + (225 \text{ lb}\cdot\text{ft})\mathbf{j}$;
 $A = -(112.5 \text{ lb})\mathbf{i} + (150.0 \text{ lb})\mathbf{j} - (75.0 \text{ lb})\mathbf{k}$.
- 4.72** $F_{CD} = 19.62 \text{ N}$; $B = (-19.22 \text{ N})\mathbf{i} + (94.2 \text{ N})\mathbf{j}$;
 $M_B = -(40.6 \text{ N}\cdot\text{m})\mathbf{i} - (17.30 \text{ N}\cdot\text{m})\mathbf{j}$.
- 4.73** $T_{BD} = 7.80 \text{ kN}$; $T_{BE} = 6.50 \text{ kN}$; $T_{CF} = 6.50 \text{ kN}$;
 $A = (19.20 \text{ kN})\mathbf{i} - (3.00 \text{ kN})\mathbf{k}$.
- 4.74** $A = (120.0 \text{ lb})\mathbf{j} - (150.0 \text{ lb})\mathbf{k}$; $B = (180.0 \text{ lb})\mathbf{i} + (150.0 \text{ lb})\mathbf{k}$;
 $C = -(180.0 \text{ lb})\mathbf{i} + (120.0 \text{ lb})\mathbf{j}$.
- 4.75** Equilibrium; $F = 172.6 \text{ N } \searrow 25.0^\circ$.
- 4.76** Block moves down; $F = 279 \text{ N } \searrow 30.0^\circ$.
- 4.77** Block moves up; $F = 36.1 \text{ lb } \searrow 30.0^\circ$.
- 4.78** Block is in equilibrium; $F = 36.3 \text{ lb } \searrow 30.0^\circ$.
- 4.80** (a) $18.09 \text{ lb } \rightarrow$. (b) $14.34 \text{ lb } \leftarrow$.
- 4.81** 31.0° .
- 4.82** 46.4° .
- 4.83** Package C does not move; Packages A and B move;
 $F_A = 7.58 \text{ N } \nearrow$; $F_B = 3.03 \text{ N } \nearrow$; $F_C = 10.16 \text{ N } \nearrow$.
- 4.85** (a) $36.0 \text{ lb } \rightarrow$. (b) $30.0 \text{ lb } \rightarrow$. (c) $12.86 \text{ lb } \rightarrow$.
- 4.87** (a) 0.485 . (b) 255 N .
- 4.88** (a) 0.377 . (b) 173.9 N .
- 4.90** (a) $275 \text{ N } \leftarrow$. (b) $196.2 \text{ N } \leftarrow$.
- 4.91** 0.208 .
- 4.93** (a) 43.6° . (b) $0.371W$.
- 4.94** (a) 136.4° . (b) $0.928W$.
- 4.95** $1.225W$.
- 4.97** 135.0 lb .
- 4.98** 2.90 ft .
- 4.99** (a) $A = 20.0 \text{ lb } \downarrow$; $B = 150.0 \text{ lb } \uparrow$.
 (b) $A = 10.00 \text{ lb } \downarrow$; $B = 140.0 \text{ lb } \uparrow$.
- 4.101** $T = 300 \text{ N}$; $B = 375 \text{ N } \searrow 36.9^\circ$.
- 4.102** (a) 499 N . (b) $457 \text{ N } \searrow 26.6^\circ$.
- 4.104** (a) 225 mm . (b) 23.1 N . (c) $C = 12.21 \text{ N}$.
- 4.105** 1.300 ft .
- 4.107** (a) $A = 0.745P \nearrow 63.4^\circ$; $C = 0.471P \searrow 45.0^\circ$.
 (b) $A = 0.812P \nearrow 60.0^\circ$; $C = 0.503P \nearrow 36.2^\circ$.
 (c) $A = 0.448P \searrow 60.0^\circ$; $C = 0.652P \nearrow 69.9^\circ$.
 (d) Rod is improperly constrained.
- 4.109** (a) 2.94 N . (b) 4.41 N .
- 4.110** (b) 2.69 lb .

CHAPTER 5

5.1 $\bar{X} = 42.2 \text{ mm}$, $\bar{Y} = 24.2 \text{ mm}$.

5.2 $\bar{X} = 3.27 \text{ in.}$, $\bar{Y} = 2.82 \text{ in.}$

5.3 $\bar{X} = 5.67 \text{ in.}$, $\bar{Y} = 5.17 \text{ in.}$

5.5 $\bar{X} = 1.643 \text{ in.}$, $\bar{Y} = 17.46 \text{ in.}$

5.6 $\bar{X} = -10.00 \text{ mm}$, $\bar{Y} = 87.5 \text{ mm}$.

5.7 $\bar{X} = -62.4 \text{ mm}$, $\bar{Y} = 0$.

5.9 $\bar{X} = \bar{Y} = 9.00 \text{ in.}$

5.10 $\bar{X} = 10.11 \text{ in.}$, $\bar{Y} = 3.88 \text{ in.}$

5.11 $\bar{X} = 11.91 \text{ mm}$, $\bar{Y} = 28.8 \text{ mm}$.

5.12 $\bar{X} = 386 \text{ mm}$, $\bar{Y} = 66.4 \text{ mm}$.

5.13 $42.3 \times 10^3 \text{ mm}^3$ for A_1 , $-42.3 \times 10^3 \text{ mm}^3$ for A_2 .

5.14 0.235 in^3 for A_1 , -0.235 in^3 for A_2 .

- 5.17** $\bar{X} = 40.9 \text{ mm}$, $\bar{Y} = 25.3 \text{ mm}$.
5.18 $\bar{X} = 3.38 \text{ in.}$, $\bar{Y} = 2.93 \text{ in.}$
5.19 $\bar{X} = 172.5 \text{ mm}$, $\bar{Y} = 97.5 \text{ mm}$.
5.20 $\bar{X} = -1.407 \text{ in.}$, $\bar{Y} = 15.23 \text{ in.}$
5.21 120.0 mm .
5.23 (a) 5.09 lb . (b) 9.48 lb $\searrow 57.5^\circ$.
5.25 $\bar{x} = 2a/3$, $\bar{y} = 2h/3$.
5.26 $\bar{x} = 2a/5$, $\bar{y} = 3h/7$.
5.29 $\bar{x} = a(3 - 4 \sin \alpha)/6(1 - \alpha)$, $\bar{y} = 0$.
5.30 $\bar{x} = 0$, $\bar{y} = 4(r_2^3 - r_1^3)/3\pi(r_2^2 - r_1^2)$.
5.31 $\bar{x} = 2a/3(4 - \pi)$, $\bar{y} = 2b/3(4 - \pi)$.
5.32 $\bar{x} = \bar{y} = 9a/20$.
5.33 $\bar{x} = 17a/130$, $\bar{y} = 11b/26$.
5.34 $\bar{x} = 5L/4$, $\bar{y} = 33a/40$.
5.35 $\bar{x} = \bar{y} = 1.027 \text{ in.}$
5.36 $\bar{x} = \bar{y} = (2a^2 - 1)/2a(1 + 2 \ln a)$.
5.37 (a) $V = 401 \times 10^3 \text{ mm}^3$; $A = 34.1 \times 10^3 \text{ mm}^2$.
 (b) $V = 492 \times 10^3 \text{ mm}^3$; $A = 41.9 \times 10^3 \text{ mm}^2$.
5.39 (a) $V = 169.0 \times 10^3 \text{ in}^3$; $A = 28.4 \times 10^3 \text{ in}^2$.
 (b) $V = 88.9 \times 10^3 \text{ in}^3$; $A = 15.48 \times 10^3 \text{ in}^2$.
5.41 31.9 liters .
5.42 0.0305 kg .
5.43 308 in^2 .
5.44 (a) 8.10 in^2 . (b) 6.85 in^2 . (c) 7.01 in^2 .
5.45 $V = 3.96 \text{ in}^2$; $W = 1.211 \text{ lb}$.
5.48 0.1916 kg .
5.49 (a) $\mathbf{R} = 7.60 \text{ kN } \downarrow$, $\bar{x} = 2.57 \text{ m}$.
 (b) $\mathbf{A} = 4.35 \text{ kN } \uparrow$; $\mathbf{B} = 3.25 \text{ kN } \uparrow$.
5.51 $\mathbf{A} = 575 \text{ lb } \uparrow$; $\mathbf{M}_A = 475 \text{ lb}\cdot\text{ft } \curvearrowright$.
5.53 $\mathbf{A} = 32.0 \text{ kN } \uparrow$; $\mathbf{M}_A = 124.0 \text{ kN}\cdot\text{m } \curvearrowright$.
5.54 $\mathbf{B} = 1360 \text{ lb } \uparrow$; $\mathbf{C} = 2360 \text{ lb } \uparrow$.
5.55 $\mathbf{A} = 90.0 \text{ lb } \uparrow$; $\mathbf{B} = 240 \text{ lb } \downarrow$.
5.56 $\mathbf{A} = 105.0 \text{ N } \uparrow$; $\mathbf{B} = 270 \text{ N } \uparrow$.
5.57 (a) $0.548L$. (b) $2\sqrt{3}$.
5.58 $-(2h^2 - 3b^2)/2(4h - 3b)$.
5.59 (a) $-0.402a$. (b) $h/a = 2/5$ or $2/3$.
5.60 27.8 mm above base of cone.
5.61 -0.0656 in.
5.63 46.8 mm .
5.65 $\bar{X} = \bar{Z} = 4.21 \text{ in.}$, $\bar{Y} = 7.03 \text{ in.}$
5.66 $\bar{X} = 125.0 \text{ mm}$, $\bar{Y} = 167.0 \text{ mm}$, $\bar{Z} = 33.5 \text{ mm}$.
5.69 $\bar{X} = 0.909 \text{ m}$, $\bar{Y} = 0.1842 \text{ m}$, $\bar{Z} = 0.884 \text{ m}$.
5.70 $\bar{X} = 0$, $\bar{Y} = 10.05 \text{ in.}$, $\bar{Z} = 5.15 \text{ in.}$
5.71 $\bar{X} = \bar{Z} = 0$, $\bar{Y} = 83.3 \text{ mm}$ above the base.
5.72 $\bar{Y} = 0.526 \text{ in.}$ above the base.
5.73 $\bar{X} = 19.27 \text{ mm}$, $\bar{Y} = 26.6 \text{ mm}$.
5.75 $\bar{X} = 20.6 \text{ mm}$, $\bar{Y} = 23.4 \text{ mm}$.
5.76 (a) 125.3 N . (b) 137.0 N $\searrow 56.7^\circ$.
5.77 $\bar{x} = 1.607a$, $\bar{y} = 0.332h$.
5.79 0.0900 in^3 .
5.81 $\mathbf{B} = 3770 \text{ lb } \uparrow$; $\mathbf{C} = 429 \text{ lb } \uparrow$.
5.82 (a) 900 lb/ft . (b) $7200 \text{ lb } \uparrow$.
5.84 $\bar{X} = 61.1 \text{ mm}$ from the end of the handle.
- 6.6** $F_{AB} = 15.90 \text{ kN } C$; $F_{AC} = 13.50 \text{ kN } T$; $F_{CD} = 15.90 \text{ kN } T$;
 $F_{BC} = 16.80 \text{ kN } C$; $F_{BD} = 13.50 \text{ kN } C$.
6.8 $F_{AB} = F_{BC} = 0$; $F_{AD} = F_{CF} = 7.00 \text{ kN } C$; $F_{BD} = F_{BF} =$
 $34.0 \text{ kN } C$; $F_{DE} = F_{EF} = 30.0 \text{ kN } T$; $F_{BE} = 8.00 \text{ kN } T$.
6.9 $F_{AB} = F_{AE} = 671 \text{ lb } T$; $F_{BC} = F_{DE} = 600 \text{ lb } C$;
 $F_{AC} = F_{AD} = 1000 \text{ lb } C$; $F_{CD} = 200 \text{ lb } T$.
6.10 $F_{AB} = 15.00 \text{ kN } T$; $F_{AD} = 17.00 \text{ kN } C$; $F_{BC} = 15.00 \text{ kN } T$;
 $F_{CE} = 8.00 \text{ kN } T$; $F_{EF} = 8.00 \text{ kN } T$; $F_{DF} = 17.00 \text{ kN } C$;
 $F_{BE} = F_{BD} = F_{DE} = 0$.
6.11 $F_{AB} = 200 \text{ lb } C$; $F_{AC} = 520 \text{ lb } T$; $F_{BC} = 520 \text{ lb } T$;
 $F_{BE} = 480 \text{ lb } C$; $F_{CD} = 520 \text{ lb } T$; $F_{CE} = 520 \text{ lb } T$;
 $F_{DE} = 200 \text{ lb } C$.
6.12 $F_{AB} = 12.00 \text{ kips } C$; $F_{AC} = 5.00 \text{ kips } C$; $F_{AD} = 13.00 \text{ kips } T$;
 $F_{CD} = 30.0 \text{ kips } C$; $F_{CE} = 17.50 \text{ kips } C$; $F_{CF} = 32.5 \text{ kips } T$;
 $F_{DF} = 5.00 \text{ kips } T$; $F_{BD} = F_{EF} = 0$.
6.13 $F_{AB} = F_{DE} = 8.00 \text{ kN } C$; $F_{AF} = F_{FG} = F_{GH} = F_{EH} =$
 $6.93 \text{ kN } T$; $F_{BC} = F_{CD} = F_{BG} = F_{DG} = 4.00 \text{ kN } C$; $F_{BF} =$
 $F_{DH} = F_{CG} = 4.00 \text{ kN } T$.
6.15 $F_{AB} = F_{FH} = 1500 \text{ lb } C$; $F_{AC} = F_{CE} = F_{EG} = F_{GH} = 1200 \text{ lb } T$;
 $F_{BC} = F_{FG} = 0$; $F_{BD} = F_{DF} = 1000 \text{ lb } C$; $F_{BE} = F_{EF} =$
 $500 \text{ lb } C$; $F_{DE} = 600 \text{ lb } T$.
6.17 $F_{AB} = 2250 \text{ N } C$; $F_{AC} = 1200 \text{ N } T$; $F_{BC} = 750 \text{ N } T$;
 $F_{BD} = 1700 \text{ N } C$; $F_{BE} = 400 \text{ N } C$; $F_{CF} = 1600 \text{ N } T$;
 $F_{CE} = 850 \text{ N } C$; $F_{DE} = 1500 \text{ N } T$; $F_{EF} = 2250 \text{ N } T$.
6.18 $F_{AB} = F_{FG} = 7.50 \text{ kips } C$; $F_{AC} = F_{EG} = 4.50 \text{ kips } T$;
 $F_{BC} = F_{EF} = 7.50 \text{ kips } T$; $F_{BD} = F_{DF} = 9.00 \text{ kips } C$;
 $F_{CD} = F_{DE} = 0$; $F_{CE} = 9.00 \text{ kips } T$.
6.19 Truss of Prob. 6.24 is the only simple truss.
6.20 Neither truss is a simple truss.
6.21 BC , CD , IJ , IL , LM , MN .
6.24 BF , BG , DH , EH , GJ , HJ .
6.25 $F_{BD} = 36.0 \text{ kips } C$; $F_{CD} = 45.0 \text{ kips } C$.
6.26 $F_{FD} = 60.0 \text{ kips } C$; $F_{GD} = 15.00 \text{ kips } C$.
6.27 $F_{BD} = 216 \text{ kN } T$; $F_{DE} = 270 \text{ kN } T$.
6.29 $F_{DE} = 25.0 \text{ kips } T$; $F_{DF} = 13.00 \text{ kips } C$.
6.31 $F_{CF} = 26.0 \text{ kN } T$; $F_{EF} = 1.118 \text{ kN } T$; $F_{EG} = 27.0 \text{ kN } C$.
6.33 $F_{CE} = 7.20 \text{ kN } T$; $F_{DE} = 1.047 \text{ kN } C$; $F_{DF} = 6.39 \text{ kN } C$.
6.34 $F_{EG} = 3.46 \text{ kN } T$; $F_{GH} = 3.78 \text{ kN } C$; $F_{HJ} = 3.55 \text{ kN } C$.
6.35 $F_{AB} = 8.20 \text{ kips } T$; $F_{AG} = 4.50 \text{ kips } T$; $F_{FG} = 11.60 \text{ kips } C$.
6.37 $F_{DF} = 40.0 \text{ kN } T$; $F_{EF} = 12.00 \text{ kN } T$; $F_{EG} = 60.0 \text{ kN } C$.
6.39 $F_{DF} = 10.48 \text{ kips } C$; $F_{DG} = 3.35 \text{ kips } C$; $F_{EG} = 13.02 \text{ kips } T$.
6.40 $F_{GI} = 13.02 \text{ kips } T$; $F_{HI} = 0.800 \text{ kips } T$; $F_{HJ} = 13.97 \text{ kips } C$.
6.41 $F_{DG} = 3.75 \text{ kN } T$; $F_{FI} = 3.75 \text{ kN } C$.
6.42 $F_{GJ} = 11.25 \text{ kN } T$; $F_{IK} = 11.25 \text{ kN } C$.
6.44 $F_{BE} = 10.00 \text{ kips } T$; $F_{DE} = 0$; $F_{EF} = 5.00 \text{ kips } T$.
6.45 $F_{BE} = 2.50 \text{ kips } T$; $F_{DE} = 1.500 \text{ kips } C$; $F_{DG} = 2.50 \text{ kips } T$.
6.47 (a) Partially constrained.
 (b) Completely constrained and determinate.
 (c) Completely constrained and indeterminate.
- 6.48** (a) Completely constrained and indeterminate.
 (b) Completely constrained and determinate.
 (c) Improperly constrained.
- 6.49** $F_{BD} = 1750 \text{ N } C$; $\mathbf{C}_x = 1400 \text{ N } \leftarrow$; $\mathbf{C}_y = 700 \text{ N } \downarrow$.
6.50 $F_{BD} = 780 \text{ lb } T$; $\mathbf{C}_x = 720 \text{ lb } \leftarrow$, $\mathbf{C}_y = 140.0 \text{ lb } \downarrow$.
6.51 (a) 125.0 N $\searrow 36.9^\circ$. (b) 125.0 N $\nearrow 36.9^\circ$.
6.52 $\mathbf{A}_x = 120.0 \text{ lb } \rightarrow$; $\mathbf{A}_y = 30.0 \text{ lb } \uparrow$; $\mathbf{B}_x = 120.0 \text{ lb } \leftarrow$,
 $\mathbf{B}_y = 80.0 \text{ lb } \downarrow$; $\mathbf{C} = 30.0 \text{ lb } \downarrow$; $\mathbf{D} = 80.0 \text{ lb } \uparrow$.
6.53 $\mathbf{A} = 150.0 \text{ lb } \rightarrow$; $\mathbf{B}_x = 150.0 \text{ lb } \leftarrow$, $\mathbf{B}_y = 60.0 \text{ lb } \uparrow$;
 $\mathbf{C} = 20.0 \text{ lb } \uparrow$; $\mathbf{D} = 80.0 \text{ lb } \downarrow$.
6.55 (a) $\mathbf{A}_x = 300 \text{ N } \leftarrow$, $\mathbf{A}_y = 660 \text{ N } \uparrow$; $\mathbf{E}_x = 300 \text{ N } \rightarrow$;
 $\mathbf{E}_y = 90.0 \text{ N } \uparrow$. (b) $\mathbf{A}_x = 300 \text{ N } \leftarrow$, $\mathbf{A}_y = 150.0 \text{ N } \uparrow$;
 $\mathbf{E}_x = 300 \text{ N } \rightarrow$, $\mathbf{E}_y = 600 \text{ N } \uparrow$.

CHAPTER 6

- 6.1** $F_{AB} = 4.00 \text{ kN } C$; $F_{BC} = 2.40 \text{ kN } C$; $F_{AC} = 2.72 \text{ kN } T$.
6.2 $F_{AB} = 52.0 \text{ kN } T$; $F_{BC} = 80.0 \text{ kN } C$; $F_{AC} = 64.0 \text{ kN } T$.
6.3 $F_{AB} = 720 \text{ lb } T$; $F_{BC} = 780 \text{ lb } C$; $F_{AC} = 1200 \text{ lb } C$.
6.4 $F_{AB} = 900 \text{ lb } T$; $F_{BC} = 720 \text{ lb } T$; $F_{AC} = 780 \text{ lb } C$.

- 6.57** $B = 152.0 \text{ lb} \downarrow$; $C_x = 60.0 \text{ lb} \leftarrow$; $C_y = 200 \text{ lb} \uparrow$;
 $D_x = 60.0 \text{ lb} \rightarrow$; $D_y = 42.0 \text{ lb} \uparrow$.
- 6.58** (a) $A_x = 2700 \text{ N} \rightarrow$; $A_y = 200 \text{ N} \uparrow$; $E_x = 2700 \text{ N} \leftarrow$;
 $E_y = 600 \text{ N} \uparrow$. (b) $A_x = 300 \text{ N} \rightarrow$; $A_y = 200 \text{ N} \uparrow$;
 $E_x = 300 \text{ N} \leftarrow$; $E_y = 600 \text{ N} \uparrow$.
- 6.59** (a) $D_x = 750 \text{ N} \rightarrow$; $D_y = 250 \text{ N} \downarrow$; $E_x = 750 \text{ N} \leftarrow$;
 $E_y = 250 \text{ N} \uparrow$.
 (b) $D_x = 375 \text{ N} \rightarrow$; $D_y = 250 \text{ N} \downarrow$; $E_x = 375 \text{ N} \leftarrow$; $E_y = 250 \text{ N} \uparrow$.
- 6.61** (a) $A = 48.0 \text{ lb} \downarrow$; $B = 108.0 \text{ lb} \uparrow$.
 (b) $A_x = 80.0 \text{ lb} \rightarrow$; $A_y = 48.0 \text{ lb} \downarrow$; $B_x = 80.0 \text{ lb} \leftarrow$;
 $B_y = 108.0 \text{ lb} \uparrow$.
- 6.62** $B = 98.5 \text{ lb} \nearrow 24.0^\circ$; $C = 90.6 \text{ lb} \searrow 6.34^\circ$.
- 6.64** (a) $828 \text{ N } T$. (b) $C = 1197 \text{ N} \searrow 86.2^\circ$.
- 6.65** $A_x = 176.3 \text{ lb} \leftarrow$; $A_y = 60.0 \text{ lb} \downarrow$; $G_x = 56.3 \text{ lb} \rightarrow$; $G_y = 510 \text{ lb} \uparrow$.
- 6.66** $A_x = 56.3 \text{ lb} \leftarrow$; $A_y = 157.5 \text{ lb} \downarrow$; $G_x = 56.3 \text{ lb} \rightarrow$; $G_y = 383 \text{ lb} \uparrow$.
- 6.67** $D_x = 13.60 \text{ kN} \rightarrow$; $D_y = 7.50 \text{ kN} \uparrow$; $E_x = 13.60 \text{ kN} \leftarrow$;
 $E_y = 2.70 \text{ kN} \downarrow$.
- 6.69** (a) $A = 75.0 \text{ kN} \uparrow$; $B = 162.5 \text{ kN} \uparrow$.
 (b) $C = 170.0 \text{ kN} \leftarrow$; $D_x = 170.0 \text{ kN} \rightarrow$; $D_y = 25.0 \text{ kN} \downarrow$.
- 6.70** (a) $A = 12.50 \text{ kN} \uparrow$; $B = 187.5 \text{ kN} \uparrow$.
 (b) $C = 30.0 \text{ kN} \leftarrow$; $D_x = 30.0 \text{ kN} \rightarrow$; $D_y = 75.0 \text{ kN} \downarrow$.
- 6.72** (a) 572 lb . (b) $A = 1070 \text{ lb} \uparrow$; $B = 709 \text{ lb} \uparrow$; $C = 870 \text{ lb} \uparrow$.
- 6.73** $564 \text{ lb} \rightarrow$.
- 6.74** $275 \text{ lb} \rightarrow$.
- 6.75** $764 \text{ N} \leftarrow$.
- 6.76** (a) $764 \text{ N} \downarrow$. (b) $565 \text{ N} \searrow 61.3^\circ$.
- 6.78** $D = 30.0 \text{ kN} \leftarrow$; $F = 37.5 \text{ kN} \searrow 36.9^\circ$.
- 6.80** $B = 94.9 \text{ lb} \nearrow 18.43^\circ$; $D = 94.9 \text{ lb} \searrow 18.43^\circ$.
- 6.81** (a) $252 \text{ N} \cdot \text{m} \curvearrowright$. (b) $108.0 \text{ N} \cdot \text{m} \curvearrowright$.
- 6.82** (a) $3.00 \text{ kN} \downarrow$. (b) $7.00 \text{ kN} \downarrow$.
- 6.83** $152.2 \text{ lb} \cdot \text{in} \cdot \curvearrowright$.
- 6.85** (a) 475 lb . (b) $528 \text{ lb} \searrow 63.3^\circ$.
- 6.86** 1200 N .
- 6.88** 720 lb .
- 6.89** $21.3 \text{ lb} \searrow$.
- 6.91** 140.0 N .
- 6.92** 260 N .
- 6.94** (a) $10.00 \text{ kN} \searrow 2.58^\circ$. (b) $10.11 \text{ kN} \searrow 8.60^\circ$.
- 6.95** (a) $3000 \text{ lb } T$. (b) $H_x = 2400 \text{ lb} \leftarrow$; $H_y = 4800 \text{ lb} \downarrow$.
- 6.96** $F_{AB} = 18.97 \text{ kips } C$; $F_{CD} = 4.27 \text{ kips } T$; $F_{EF} = 9.61 \text{ kips } C$.
- 6.97** $F_{AB} = 420 \text{ lb } C$; $F_{AC} = 400 \text{ lb } T$; $F_{AD} = 260 \text{ lb } C$;
 $F_{BC} = 125.0 \text{ lb } T$; $F_{BE} = 832 \text{ lb } C$; $F_{CE} = 400 \text{ lb } T$;
 $F_{DC} = 125.0 \text{ lb } T$.
- 6.99** $F_{AF} = 1.500 \text{ kN } T$; $F_{EJ} = 0.900 \text{ kN } T$.
- 6.100** $F_{HJ} = 33.8 \text{ kips } C$; $F_{IL} = 33.8 \text{ kips } T$.
- 6.101** $7.36 \text{ kN } C$.
- 6.103** $A_x = 3.32 \text{ kN} \leftarrow$; $A_y = 14.26 \text{ kN} \downarrow$;
 $C_x = 3.72 \text{ kN} \rightarrow$; $C_y = 14.26 \text{ kN} \uparrow$.
- 6.104** 31.3 lb .
- 6.106** (a) $E_x = 2.00 \text{ kips} \leftarrow$; $E_y = 2.25 \text{ kips} \uparrow$.
 (b) $C_x = 4.00 \text{ kips} \leftarrow$; $C_y = 5.75 \text{ kips} \uparrow$.
- 6.108** $B_x = 700 \text{ N} \leftarrow$; $B_y = 200 \text{ N} \downarrow$;
 $E_x = 700 \text{ N} \rightarrow$; $E_y = 500 \text{ N} \uparrow$.

CHAPTER 7

- 7.1** $a^3(h_1 + 3h_2)/12$.
7.2 $3a^3b/10$.
7.3 $ha^3/5$.
7.4 $2a^3b/15$.

- 7.5** $a(h_1^2 + h_2^2)(h_1 + h_2)/12$.
7.6 $a^3b/6$.
7.9 $\pi ab^3/8$; $b/2$.
7.10 $0.525ah^3$; $1.202h$.
7.11 $ab^3/30$; $b/\sqrt{10}$.
7.12 $3ab^3/35$; $0.507b$.
7.13 $\pi a^3b/8$; $a/2$.
7.14 $0.613a^3h$; $1.299a$.
7.17 (a) $J_O = 4a^4/3$; $r_O = 0.816a$. (b) $J_O = 17a^4/6$; $r_O = 1.190a$.
7.18 $J_O = 10a^4/3$; $r_O = 1.291a$.
7.20 $4ab(a^2 + 4b^2)/3$; $\sqrt{(a^2 + 4b^2)/3}$.
7.21 $(\pi/2)(R_2^4 - R_1^4)$; $(\pi/4)(R_2^4 - R_1^4)$.
7.23 $4a^3/9$.
7.24 $0.935a$.
7.25 $390 \times 10^3 \text{ mm}^4$; 21.9 mm .
7.26 46.0 in^4 ; 1.599 in .
7.27 $501 \times 10^6 \text{ mm}^4$; 149.4 mm .
7.30 46.5 in^4 ; 1.607 in .
7.31 $150.3 \times 10^6 \text{ mm}^4$; 81.9 mm .
7.32 185.4 in^4 ; 2.81 in .
7.33 $\bar{I}_x = 1.500 \times 10^6 \text{ mm}^4$; $\bar{I}_y = 3.00 \times 10^6 \text{ mm}^4$.
7.35 $\bar{I}_x = 191.3 \text{ in}^4$; $\bar{I}_y = 75.2 \text{ in}^4$.
7.36 $\bar{I}_x = 479 \times 10^3 \text{ mm}^4$; $\bar{I}_y = 149.7 \times 10^3 \text{ mm}^4$.
7.38 (a) 765 in^4 . (b) 402 in^4 .
7.39 (a) $3.13 \times 10^6 \text{ mm}^4$. (b) $2.41 \times 10^6 \text{ mm}^4$.
7.40 (a) 129.2 in^4 . (b) 25.8 in^4 .
7.41 $\bar{I}_x = 254 \text{ in}^4$; $\bar{r}_x = 4.00 \text{ in}$; $\bar{I}_y = 102.1 \text{ in}^4$; $\bar{r}_y = 2.54 \text{ in}$.
7.43 $\bar{I}_x = 255 \times 10^6 \text{ mm}^4$; $\bar{r}_x = 134.1 \text{ mm}$;
 $\bar{I}_y = 100.0 \times 10^6 \text{ mm}^4$; $\bar{r}_y = 83.9 \text{ mm}$.
7.44 $\bar{I}_x = 260 \times 10^6 \text{ mm}^4$; $\bar{r}_x = 144.6 \text{ mm}$;
 $\bar{I}_y = 17.53 \times 10^6 \text{ mm}^4$; $\bar{r}_y = 37.6 \text{ mm}$.
7.45 1.077 in .
7.46 $\bar{I}_x = 9.54 \text{ in}^4$; $\bar{I}_y = 104.5 \text{ in}^4$.
7.47 $\bar{I}_x = 3.55 \times 10^6 \text{ mm}^4$; $\bar{I}_y = 49.8 \times 10^6 \text{ mm}^4$.
7.49 $b^3h/12$.
7.51 $0.0945ah^3$; $0.402h$.
7.53 $bh(12h^2 + b^2)/48$; $\sqrt{(12h^2 + b^2)/24}$.
7.54 $\bar{I}_x = 1.268 \times 10^6 \text{ mm}^4$; $\bar{I}_y = 339 \times 10^3 \text{ mm}^4$.
7.55 $\bar{I}_x = 1.874 \times 10^6 \text{ mm}^4$; $\bar{I}_y = 5.82 \times 10^6 \text{ mm}^4$.
7.56 $\bar{I}_x = 48.9 \times 10^3 \text{ mm}^4$; $\bar{I}_y = 8.35 \times 10^3 \text{ mm}^4$.
7.58 (a) $12.16 \times 10^6 \text{ mm}^4$. (b) $9.73 \times 10^6 \text{ mm}^4$.
7.60 (a) 6.57 in . (b) $\bar{I}_x = \bar{I}_y = 3350 \text{ in}^4$.

CHAPTER 8

- 8.1** (a) 35.7 MPa . (b) 42.4 MPa .
8.2 $d_1 = 22.6 \text{ mm}$; $d_2 = 15.96 \text{ mm}$.
8.3 (a) 12.73 ksi . (b) -2.83 ksi .
8.4 28.2 kips .
8.6 (a) 101.6 MPa . (b) -21.7 MPa .
8.7 1.084 ksi .
8.9 13.58 ksi .
8.10 0.400 in^2 .
8.11 (a) 17.86 kN . (b) -41.4 MPa .
8.12 -4.97 MPa .
8.14 159.2 MPa .
8.16 12.57 kips .
8.17 10.82 in .
8.19 29.4 mm .
8.20 (a) 25.9 mm . (b) 271 MPa .
8.21 (a) 8.92 ksi . (b) 22.4 ksi . (c) 11.21 ksi .
8.22 (a) 10.84 ksi . (b) 5.11 ksi .

AN6 Answers to Problems

- 8.24** (a) 5.57 mm. (b) 38.9 MPa. (c) 35.0 MPa.
8.25 $\sigma = 489 \text{ kPa}$; $\tau = 489 \text{ kPa}$.
8.26 (a) 13.95 kN. (b) 620 kPa.
8.27 $\sigma = 70.0 \text{ psi}$, $\tau = 40.4 \text{ psi}$.
8.28 (a) 1.500 kips. (b) 43.3 psi.
8.30 (a) 180.0 kips. (b) 45.0° . (c) -2.50 ksi . (d) -5.00 ksi .
8.31 $\sigma = -21.6 \text{ MPa}$, $\tau = 7.87 \text{ MPa}$.
8.33 168.1 mm^2 .
8.34 (a) 1.141 in. (b) 1.549 in.
8.35 (a) 3.35. (b) 1.358 in.
8.36 1.732 kN.
8.38 1.800.
8.39 146.8 mm.
8.41 (a) 1.550 in. (b) 8.05 in.
8.42 3.47.
8.44 2.06 kN.
8.46 283 lb.
8.47 2.42.
8.48 2.05.
8.49 (a) 3.33 MPa. (b) 525 mm.
8.51 25.2 mm.
8.53 (a) -640 psi . (b) -320 psi .
8.54 3.09 kips.
8.55 (a) 94.1 MPa. (b) 44.3 MPa.
8.57 27.8 mm.
8.59 $x_E = 24.7 \text{ in.}$; $x_F = 55.2 \text{ in.}$
8.60 285 mm^2 .

CHAPTER 9

- 9.1** (a) 0.0303 in. (b) 15.28 ksi.
9.2 (a) 81.8 MPa. (b) 1.712.
9.3 (a) 0.546 mm. (b) 36.3 MPa.
9.4 (a) 9.82 kN. (b) 500 MPa.
9.5 (a) 0.0206 in. (b) 1.20%.
9.8 (a) 2.50 ksi. (b) 0.1077 in.
9.9 0.0252 in.
9.11 1.988 kN.
9.12 0.429 in.
9.13 0.868 in.
9.14 (a) 0.781 mm \downarrow . (b) 5.71 mm \downarrow .
9.15 (a) 0.794 mm. (b) 0.484 mm.
9.17 0.1812 in.
9.18 (a) -0.1549 mm . (b) 0.1019 mm \downarrow .
9.19 50.4 kN.
9.20 $S_{BD} = +79.4 \times 10^{-3} \text{ in.}$; $S_{DE} = +124.1 \times 10^{-3} \text{ in.}$
9.21 1.066 kips.
9.24 (a) 1.222 mm. (b) 1.910 mm.
9.25 (a) 65.1 MPa. (b) 0.279 mm.
9.26 (a) 287 kN. (b) 140.0 MPa.
9.27 $\sigma_s = -12.84 \text{ ksi}$; $\sigma_c = -1.594 \text{ ksi}$.
9.28 201 kips.
9.30 (a) 62.8 kN \leftarrow at A; 37.2 kN \leftarrow at E. (b) $46.3 \mu\text{m} \rightarrow$.
9.32 (a) $\mathbf{R}_A = 2.28 \text{ kips} \uparrow$; $\mathbf{R}_C = 9.72 \text{ kips} \uparrow$.
 (b) $\sigma_{AB} = +1.857 \text{ ksi}$; $\sigma_{BC} = -3.09 \text{ ksi}$.
9.33 177.4 lb.
9.35 A: 0.525P; B: 0.200P; C: 0.275P.
9.36 A: 0.1P; B: 0.2P; C: 0.3P; D: 0.4P.
9.37 137.8°F .
9.39 $\sigma_s = -1.448 \text{ ksi}$; $\sigma_c = 54.2 \text{ psi}$.
9.40 (a) -98.3 MPa . (b) -38.3 MPa .
9.41 142.6 kN.

- 9.42** (a) $\sigma_{AB} = -5.25 \text{ ksi}$; $\sigma_{BC} = -11.82 \text{ ksi}$.
 (b) $6.57 \times 10^{-3} \text{ in.} \rightarrow$.
9.44 (a) 52.3 kips. (b) $9.91 \times 10^{-3} \text{ in.}$
9.45 (a) 201.6°F . (b) 18.0107 in.
9.46 (a) -116.2 MPa . (b) 0.363 mm.
9.48 (a) 21.4°C . (b) 3.67 MPa.
9.49 (a) 0.1973 mm. (b) -0.00651 mm .
9.52 94.9 kips.
9.53 1.99551 : 1.
9.54 (a) 0.0358 mm. (b) -0.00258 mm . (c) -0.000344 mm .
 (d) -0.00825 mm^2 .
9.55 (a) $5.13 \times 10^{-3} \text{ in.}$ (b) $-0.570 \times 10^{-3} \text{ in.}$
9.56 (a) 7630 lb compression. (b) 4580 lb compression.
9.58 (a) 0.0754 mm. (b) 0.1028 mm. (c) 0.1220 mm.
9.62 10.26 MPa.
9.63 $6.17 \times 10^3 \text{ kN/m}$.
9.64 (a) 10.42 in. (b) 0.813 in.
9.65 (a) 13.31 ksi. (b) 18.72 ksi.
9.67 (a) 58.3 kN. (b) 64.3 kN.
9.68 (a) 87.0 MPa. (b) 75.2 MPa. (c) 73.9 MPa.
9.69 (a) 12.02 kips. (b) 108.0%.
9.70 23.9 kips.
9.72 36.7 mm.
9.73 1.219 in.
9.74 21.5 kN.
9.76 (a) $80.4 \mu\text{m} \uparrow$. (b) $209 \mu\text{m} \downarrow$. (c) $390 \mu\text{m} \downarrow$.
9.77 0.536 mm \downarrow .
9.80 (a) 145.9°F . (b) 0.01053 in.
9.81 (a) -63.0 MPa . (b) -4.05 mm^2 . (c) -162.0 mm^3 .
9.82 $a = 42.9 \text{ mm}$; $b = 160.7 \text{ mm}$.
9.83 (a) $3/4 \text{ in.}$ (b) 15.63 kips.




CHAPTER 10

- 10.1** 641 N-m.
10.2 87.3 MPa.
10.3 (a) 7.55 ksi. (b) 7.64 ksi.
10.4 (a) 125.7 N-m (b) 181.4 N-m.
10.6 (a) 7.55 ksi. (b) 3.49 in.
10.8 (a) 1.292 in. (b) 1.597 in.
10.9 (a) 2.85 ksi. (b) 4.46 ksi. (c) 5.37 ksi.
10.10 (a) 3.19 ksi. (b) 4.75 ksi. (c) 5.58 ksi.
10.12 39.8 mm.
10.13 9.16 kip-in.
10.15 (a) 1.473 kN-m. (b) 43.7 mm.
10.16 (a) 50.3 mm. (b) 63.4 mm.
10.17 AB: 42.0 mm; BC: 33.3 mm.
10.18 AB: 52.9 mm; BC: 33.3 mm.
10.20 1.189 kip-in.
10.21 73.6 N-m.
10.23 (a) 1.442 in. (b) 1.233 in.
10.24 4.30 kip-in.
10.25 (a) 2.83 kip-in. (b) 13.00° .
10.26 (a) 3.74° . (b) 3.79° .
10.28 9.38 ksi.
10.30 (a) 1.384° . (b) 3.22° .
10.31 (a) 14.43° . (b) 46.9° .
10.32 6.02° .
10.33 12.22° .
10.34 3.78° .
10.36 $(T_A/IGJ)(1/n^4 + 1/n^2 + 1)$.

- 10.37** 36.1 mm.
10.39 0.837 in.
10.40 1.089 in.
10.41 (a) 73.6 MPa. (b) 34.4 MPa. (c) 5.07° .
10.43 (a) 4.50 ksi. (b) 6.06 ksi.
10.44 (a) 9.19 ksi. (b) 4.08 ksi.
10.45 (a) A: 1105 N·m; C: 295 N·m.
 (b) 45.0 MPa. (c) 27.4 MPa.
10.46 (a) $T_A = 1090$ N·m; $T_C = 310$ N·m.
 (b) 47.4 MPa. (c) 28.8 MPa.
10.48 1.483 in.
10.49 12.44 ksi.
10.51 7.95 kip-in.
10.52 (a) 12.63 kip-in. (b) 1.093° .
10.54 1.221.
10.56 127.8 lb-in.
10.58 $\tau_{AB} = 68.9$ MPa; $\tau_{CD} = 14.70$ MPa.
10.59 $\tau_{AB} = 10.27$ MPa; $\tau_{CD} = 48.6$ MPa.
10.60 12.24 MPa.

CHAPTER 11

- 11.1** (a) -116.4 MPa. (b) -87.3 MPa.
11.2 (a) -2.38 ksi. (b) -0.650 ksi.
11.3 80.2 kN·m.
11.4 24.8 kN·m.
11.6 (a) 1.405 kip-in. (b) 3.19 kip-in.
11.7 259 kip-in.
11.9 top: -14.71 ksi; bottom: 8.82 ksi.
11.10 top: -81.8 MPa; bottom: 67.8 MPa.
11.12 3.79 kN·m.
11.13 (a) 8.24 kips. (b) 1.332 kips.
11.15 61.3 kN.
11.16 4.11 kip-in.
11.17 7.67 kN·m.
11.18 42.9 kip-in.
11.19 106.1 N·m.
11.21 4.63 kip-in.
11.23 (a) $\sigma = 75$ MPa, $\rho = 26.7$ m. (b) $\sigma = 125.0$ MPa, $\rho = 9.60$ m.
11.24 (a) $\sigma_{\max} = 6M/a^3$, $1/\rho = 12M/Ea^4$.
 (b) $\sigma_{\max} = 8.49M/a^3$, $1/\rho = 12M/Ea^4$.
11.25 1.240 kN·m.
11.26 887 N·m.
11.27 720 N·m.
11.29 335 kip-in.
11.30 193.6 kip-in.
11.31 (a) -56.0 MPa. (b) 66.4 MPa.
11.32 (a) -56.9 MPa. (b) 111.9 MPa.
11.33 (a) -1.979 ksi. (b) 16.48 ksi.
11.36 43.7 m.
11.37 625 ft.
11.38 625 ft.
11.39 (a) 212 MPa. (b) -15.59 MPa.
11.40 (a) 210 MPa. (b) -14.08 MPa.
11.42 2.88 kip-ft.
11.43 (a) 24.1 ksi. (b) -1.256 ksi.
11.44 33.9 kip-ft.
11.46 (a) steel: 8.96 ksi; aluminum: 1.792 ksi; brass: 0.896 ksi.
 (b) 349 ft.
11.48 (a) 54.1 MPa. (b) 130.2 MPa.
11.49 (a) $-2P/\pi r^2$ (b) $-5P/\pi r^2$.
11.50 (a) -105.0 psi. (b) -195.0 psi.

- 11.51** (a) -212 psi. (b) -637 psi. (c) -1061 psi.
11.52 (a) 71.0 MPa. (b) -80.2 MPa.
11.53 (a) 112.7 MPa. (b) -96.0 MPa.
11.54 (a) 130.2 MPa. (b) -110.0 MPa.
11.57 0.375d.
11.58 0.455 in.
11.59 (a) -0.750 ksi. (b) -2.00 ksi. (c) -1.500 ksi.
11.60 623 lb.
11.62 16.04 mm.
11.64 (a) 2.54 kN. (b) 17.01 mm to the right of loads.
11.65 (a) $-P/2at$. (b) $2P/at$. (c) $-P/2at$.
11.66 (a) 52.7 MPa. (b) -62.7 MPa. (c) 11.20 mm above D.
11.68 23.0 kips.
11.70 $P = 44.2$ kips, $Q = 57.3$ kips.
11.71 (a) 30.0 mm. (b) 94.5 kN.
11.72 (a) 5.00 mm. (b) 243 kN.
11.73 (a) 9.86 ksi. (b) -2.64 ksi. (c) -9.86 ksi.
11.74 (a) -29.3 MPa. (b) -144.8 MPa. (c) -125.9 MPa.
11.75 (a) 1.149 ksi. (b) 0.1479 ksi. (c) -1.149 ksi.
11.76 (a) 7.20 ksi. (b) -18.39 ksi. (c) -7.20 ksi.
11.78 (a) 57.8 MPa. (b) -56.8 MPa. (c) 25.9 MPa.
11.79 (a) 11.3° . (b) 15.06 ksi.
11.80 (a) 57.4° . (b) 75.7 MPa.
11.82 (a) 10.03° . (b) 54.2 MPa.
11.83 (a) 27.5° . (b) 5.07 ksi.
11.84 (a) 32.9° . (b) 61.4 MPa.
11.85 (a) $\sigma_A = 41.7$ psi; $\sigma_B = 292$ psi. (b) AB: 0.500 in. from A;
 BD: 0.750 in. from D.
11.87 (a) $\sigma_A = 31.5$ MPa; $\sigma_B = -10.39$ MPa. (b) 94.0 mm above A.
11.89 0.1638 in.
11.91 (a) 9.23 MPa. (b) -11.92 MPa. (c) Neutral axis intersects AB
 at 69.8 mm from point A.
11.93 121.6 MPa; -143.0 MPa.
11.94 (a) 9.17 kN·m. (b) 10.24 kN·m.
11.96 65.1 ksi.
11.97 73.2 MPa; -102.4 MPa.
11.99 (a) -1.526 ksi. (b) 17.67 ksi.
11.101 (a) 46.7° . (b) 80.2 MPa.
11.102 (a) 288 lb. (b) 209 lb.
11.104 (a) 1.414. (b) 1.732.

CHAPTER 12

- 12.1** (b) A to B: $V = P$; $M = Px$. B to C: $V = 0$; $M = Pa$.
 C to D: $V = -P$; $M = P(L - x)$.
12.2 (a) $V_{\max} = wL/2$, $V_{\min} = -wL/2$; $M_{\max} = wL^2/8$.
 (b) $V = w(L/2 - x)$; $M = wx(L - x)/2$.
12.3 (b) $V = w_0L/2 - w_0x^2/2L$;
 $M = -w_0L^2/3 + w_0Lx/2 - w_0x^3/6L$.
12.4 (a) $|V|_{\max} = w(L - 2a)/2$; $|M|_{\max} = w(L^2/8 - a^2/2)$.
 (b) $0 \leq x \leq a$: $V = w(L - 2a)/2$; $M = w(L - 2a)x/2$;
 $a \leq x \leq L - a$: $V = w(L/2 - x)$; $M = w[x(L - x) - a^2]/2$.
 $L - a \leq x \leq L$: $V = -w(L - 2a)/2$; $M = w(L - 2a)(L - x)/2$.
12.5 (a) 430 lb. (b) 1200 lb-in.
12.7 (a) 72.0 kN. (b) 96.0 kN·m.
12.9 (a) 10.00 kN. (b) 2.40 kN·m.
12.10 (a) 690 lb. (b) 9000 lb-in.
12.11 (a) 12.00 kips. (b) 27.0 kip-ft.
12.12 (a) 900 N. (b) 112.5 N·m.
12.13 950 psi.
12.14 10.89 MPa.
12.15 129.2 MPa.

- 12.16** 129.5 MPa.
12.17 9.90 ksi.
12.19 $|V|_{\max} = 27.5$ kips; $|M|_{\max} = 45.0$ kip-ft; $\sigma = 14.17$ ksi.
12.20 $|V|_{\max} = 279$ kN; $|M|_{\max} = 326$ kN-m; $\sigma = 136.6$ MPa.
12.23 $|V|_{\max} = 28.8$ kips; $|M|_{\max} = 56.0$ kip-ft; $\sigma = 13.05$ ksi.
12.24 $|V|_{\max} = 1.500$ kips; $|M|_{\max} = 3.00$ kip-ft; $\sigma = 2.11$ ksi.
12.25 (a) 866 mm. (b) 99.2 MPa.
12.26 (a) 819 mm. (b) 89.5 MPa.
12.27 (a) 1.260 ft. (b) 7.24 ksi.
12.29 See Prob. 12.1.
12.30 See Prob. 12.2.
12.31 See Prob. 12.3.
12.32 See Prob. 12.4.
12.33 See Prob. 12.5.
12.35 See Prob. 12.7.
12.37 (a) 1.800 kips. (b) 6.00 kip-ft.
12.38 (a) 880 lb. (b) 2000 lb-ft.
12.39 (a) 6.00 kN. (b) 6.00 kN-m.
12.40 (a) 600 N. (b) 180.0 N-m.
12.41 See Prob. 12.13.
12.42 10.89 MPa.
12.43 129.2 MPa.
12.44 See Prob. 12.17.
12.45 (a) $V = (w_0 L/\pi) \cos(\pi x/L)$; $M = (w_0 L^2/\pi^2) \sin(\pi x/L)$.
 (b) $w_0 L^2/\pi^2$.
12.47 (a) $V = w_0(L^2 - 3x^2)/6L$; $M = w_0(Lx - x^3/L)/6$.
 (b) $0.0642w_0 L^2$.
12.49 $|V|_{\max} = 20.7$ kN; $|M|_{\max} = 9.75$ kN-m; $\sigma_{\max} = 60.2$ MPa.
12.50 $|V|_{\max} = 128.0$ kN; $|M|_{\max} = 89.6$ kN-m; $\sigma_{\max} = 156.1$ MPa.
12.51 $|V|_{\max} = 1670$ lb; $|M|_{\max} = 2640$ lb-ft; $\sigma_{\max} = 959$ psi.
12.52 $|V|_{\max} = 15.75$ kips; $|M|_{\max} = 27.8$ kip-ft; $\sigma_{\max} = 13.58$ ksi.
12.54 $|V|_{\max} = 9.28$ kips; $|M|_{\max} = 28.2$ kip-in; $\sigma_{\max} = 11.58$ ksi.
12.55 $|V|_{\max} = 76.0$ kN; $|M|_{\max} = 67.3$ kN-m; $\sigma_{\max} = 68.5$ MPa.
12.57 $h = 173.2$ mm.
12.58 $h > 203$ mm.
12.60 $b = 6.20$ in.
12.62 $a = 6.67$ in.
12.63 $W27 \times 84$.
12.64 $W27 \times 84$.
12.65 $W530 \times 66$.
12.66 $W250 \times 28.4$.
12.67 $S460 \times 81.4$.
12.69 $S12 \times 31.8$.
12.71 $C9 \times 15$.
12.72 $C180 \times 14.6$.
12.73 $3/8$ in.
12.74 9 mm.
12.77 (a) 7.00 lb. (b) 57.0 lb-in.
12.78 (a) 85.0 N. (b) 21.3 N-m.
12.80 $|V|_{\max} = 342$ N; $|M|_{\max} = 51.6$ N-m; $\sigma_{\max} = 17.19$ MPa.
12.81 $|V|_{\max} = 144.0$ kN; $|M|_{\max} = 84.0$ kN-m; $\sigma_{\max} = 99.5$ MPa.
12.84 $|V|_{\max} = 30.0$ lb; $|M|_{\max} = 24.0$ lb-ft; $\sigma_{\max} = 6.95$ ksi.
12.85 11.74 in.
12.87 7.32 kN.

CHAPTER 13

- 13.1** 92.6 lb.
13.2 326 lb.
13.3 738 N.

- 13.4** 747 N.
13.5 180.3 kN.
13.7 12.01 ksi.
13.9 (a) 7.40 ksi. (b) 6.70 ksi.
13.10 (a) 3.17 ksi. (b) 2.40 ksi.
13.11 (a) 920 kPa. (b) 765 kPa.
13.12 (a) 8.97 MPa. (b) 8.15 MPa.
13.13 14.05 in.
13.14 87.3 mm.
13.17 (a) 31.0 MPa. (b) 23.2 MPa.
13.18 (a) 1.744 ksi. (b) 2.81 ksi.
13.19 32.7 MPa.
13.20 3.21 ksi.
13.22 2.00.
13.24 1.500.
13.25 (a) 239 kPa. (b) 359 kPa.
13.26 1.672 in.
13.27 1835 lb.
13.28 (a) 12.21 MPa. (b) 58.6 MPa.
13.29 (a) 95.2 MPa. (b) 112.8 MPa.
13.31 $\tau_a = 3.93$ ksi; $\tau_b = 2.67$ ksi; $\tau_c = 0.631$ ksi;
 $\tau_d = 1.022$ ksi; $\tau_e = 0$.
13.33 (a) 41.4 MPa. (b) 41.4 MPa.
13.34 $\tau_a = 33.7$ MPa; $\tau_b = 75.0$ MPa; $\tau_c = 43.5$ MPa.
13.35 (a) 40.5 psi. (b) 55.2 psi.
13.36 (a) 2.67 in. (b) 41.6 psi.
13.37 9.05 mm.
13.39 7.19 ksi.
13.41 (a) 23.2 MPa. (b) 35.2 MPa.
13.42 10.76 MPa at a , 0 at b , 11.21 MPa at c , 22.0 MPa at d ,
 9.35 MPa at e .
13.43 10.53 ksi.
13.46 (a) 23.3 MPa. (b) 109.7 kPa.
13.48 (a) 1.323 ksi. (b) 1.329 ksi.
13.49 (a) 0.888 ksi. (b) 1.453 ksi.
13.50 (a) 155.8 N. (b) 329 kPa.
13.51 11.54 kips.
13.53 (b) $h = 225$ mm, $b = 61.7$ mm.
13.55 211 kN.
13.56 (a) 379 kPa; (b) 0.
13.57 189.6 lb.
13.58 1.167 ksi at a , 0.513 ksi at b , 4.03 ksi at c , 8.40 ksi at d .
13.60 1.422 in.

CHAPTER 14

- 14.1** $\sigma = -6.07$ MPa; $\tau = 24.9$ MPa.
14.2 $\sigma = 14.19$ MPa; $\tau = 15.19$ MPa.
14.3 $\sigma = -0.0782$ ksi, $\tau = 8.46$ ksi.
14.4 $\sigma = 10.93$ ksi, $\tau = 0.536$ ksi.
14.5 (a) -31.0° , 59.0° . (b) $\sigma_{\max} = 52.0$ MPa; $\sigma_{\min} = -84.0$ MPa.
14.7 (a) 14.0° , 104.0° . (b) 20.0 ksi, -14.00 ksi.
14.9 (a) 14.04° , 104.04° . (b) 68.0 MPa. (c) -16.00 MPa.
14.10 (a) 31.7° , 121.7° . (b) 55.9 MPa. (c) 10.00 MPa.
14.12 (a) -26.6° , 63.4° . (b) 5.00 ksi. (c) 6.00 ksi.
14.13 (a) $\sigma_x = -2.40$ ksi; $\tau_{xy} = 0.1498$ ksi; $\sigma_y = 10.40$ ksi.
 (b) $\sigma_x = 1.951$ ksi; $\tau_{xy} = 6.07$ ksi; $\sigma_y = 6.05$ ksi.
14.14 (a) $\sigma_x = 9.02$ ksi; $\tau_{xy} = 3.80$ ksi; $\sigma_y = -13.02$ ksi.
 (b) $\sigma_x = 5.34$ ksi; $\tau_{xy} = -9.06$ ksi; $\sigma_y = -9.34$ ksi.

- 14.16** (a) $\sigma_x = -37.5$ MPa, $\tau_{xy} = -25.4$ MPa, $\sigma_y = 57.5$ MPa.
 (b) $\sigma_x = -30.1$ MPa, $\tau_{xy} = 35.9$ MPa, $\sigma_y = 50.1$ MPa.
14.17 (a) -0.600 MPa. (b) -3.84 MPa.
14.18 (a) 217 psi. (b) -125.0 psi.
14.19 (a) 47.9 MPa. (b) 102.7 MPa.
14.20 (a) 18.4° . (b) 16.67 ksi.
14.22 $\sigma_a = 5.12$ ksi, $\sigma_b = -1.640$ ksi, $\tau_{\max} = 3.38$ ksi.
14.24 205 MPa.
14.25 See 14.5 and 14.9.
14.26 $\theta_p = 13.28^\circ$ and 76.7° ; $\sigma_{\max} = 65.9$ MPa; $\sigma_{\min} = -45.9$ MPa.
 See 14.10.
14.28 See 14.12.
14.29 See 14.13.
14.30 See 14.14.
14.32 See 14.16.
14.33 See 14.17.
14.34 See 14.18.
14.35 See 14.19.
14.36 See 14.20.
14.38 See 14.22.
14.40 205 MPa.
14.41 (a) 7.94 ksi. (b) 13.00 ksi, -11.00 ksi.
14.43 (a) -2.89 MPa. (b) 12.77 MPa, 1.226 MPa.
14.44 $-45^\circ \leq \theta \leq 8.13^\circ$; $45^\circ \leq \theta \leq 98.1^\circ$.
14.46 24.6° , 114.6° ; 72.9 MPa, 27.1 MPa.
14.47 0° , 90° ; σ_0 , $-\sigma_0$.
14.48 0° , 90° ; $1.732\sigma_0$, $-1.732\sigma_0$.
14.49 166.5 psi.
14.50 $\sigma = 11.82$ ksi; $\tau = 5.91$ ksi.
14.51 5.49.
14.52 (a) 95.7 MPa. (b) 1.699 mm.
14.53 (a) 1.290 MPa. (b) 0.0852 mm.
14.54 7.71 mm.
14.56 43.3 ft.
14.57 $\sigma_{\max} = 16.62$ ksi; $\tau_{\max} = 8.31$ ksi.
14.59 $\sigma_{\max} = 89.0$ MPa; $\tau_{\max} = 44.5$ MPa.
14.60 12.55 mm.
14.62 474 psi.
14.64 2.17 MPa.
16.65 (a) 44.2 MPa. (b) 15.39 MPa.
14.66 56.8° .
14.68 $\sigma_{\max} = 45.1$ MPa, $\tau_{\max(\text{in-plane})} = 7.49$ MPa.
14.69 (a) 3.15 ksi. (b) 1.993 ksi.
14.71 $\sigma_{\max} = 8.48$ ksi; $\tau_{\max} = 2.85$ ksi.
14.72 $\sigma_{\max} = 13.09$ ksi; $\tau_{\max} = 3.44$ ksi.
14.74 $-5.15^\circ \leq \theta \leq 132.0^\circ$.
14.75 3.00 ksi $\leq \sigma_x \leq 27.0$ ksi.
14.77 $\theta_p = 18.40^\circ$, 108.4° ; $\sigma_{\max} = 7.00$ ksi; $\sigma_{\min} = -3.00$ ksi.
14.78 (a) 6.40 ksi. (b) 4.70 ksi.
14.80 (a) 399 kPa. (b) 186.0 kPa.
14.81 (a) $\theta_p = 18.90^\circ$, 108.9° ; $\sigma_{\max} = 18.67$ MPa;
 $\sigma_{\min} = -158.5$ MPa. (b) 88.6 MPa.
14.83 $\sigma_{\max} = 68.6$ MPa, $\tau_{\max(\text{in-plane})} = 23.6$ MPa.
14.84 17.06 kN·m.
- 15.3** (a) $y = -w_0(2x^5 - 5Lx^4 + 10L^4x - 7L^5)/120EIL$.
 (b) $7w_0L^4/120EI \uparrow$. (c) $w_0L^3/12EI \searrow$.
15.4 (a) $y = -w(x^4 - 4L^3x + 3L^4)/24EI$. (b) $wL^4/8EI \downarrow$.
 (c) $wL^3/6EI \nearrow$.
15.6 (a) $y = w(-4x^4 + 12ax^3 - 9a^2x^2)/96EI$.
 (b) $wa^4/96EI \downarrow$. (c) $wa^3/48EI \nearrow$.
15.7 (a) $y = w(-x^4 + L^3x)/24EI$.
 (b) $wL^3/24EI \nearrow$. (c) $wL^3/8EI \searrow$.
15.9 (a) 2.79×10^{-3} rad \searrow . (b) 1.859 mm \downarrow .
15.10 (a) 3.92×10^{-3} rad \searrow . (b) 0.1806 in. \downarrow .
15.11 (a) $x_m = 0.423L$, $y_m = 0.06415M_0L^2/EI \uparrow$. (b) 45.3 kN·m.
15.12 (a) $x_m = 0.519L$, $y_m = 0.00652w_0L^4/EI \downarrow$. (b) 0.229 in. \downarrow .
15.14 0.412 in. \uparrow .
15.15 (a) $y = w_0(x^6/90 - Lx^5/30 + L^3x^3/18 - L^5x/30)/EIL^2$.
 (b) $w_0L^3/30EI \searrow$. (c) $61w_0L^4/5760EI \downarrow$.
15.17 $3wL/8$.
15.18 $3M_0/2L \uparrow$.
15.20 $11w_0L/40 \uparrow$.
15.21 $R_A = 11P/16 \uparrow$, $M_A = 3PL/16 \curvearrowright$, $R_B = 5P/16 \uparrow$, $M_B = 0$;
 $M = -3PL/16$ at A, $M = 5PL/32$ at C, $M = 0$ at B.
15.22 $R_A = 7wL/128 \uparrow$; $M = 0.0273wL^2$ at C, $M = -0.0703wL^2$ at B,
 $M = 0.0288wL^2$ at $x = 0.555L$.
15.23 $R_A = 14P/27 \uparrow$; $y_D = 20PL^3/2187EI \downarrow$.
15.25 $R_A = \frac{1}{2}P \uparrow$, $M_A = PL/8 \curvearrowright$; $M = -PL/8$ at A,
 $M = PL/8$ at C, $M = -PL/8$ at B.
15.26 $R_A = 3M_0/2L \uparrow$, $M_A = M_0/4 \curvearrowright$; $M = M_0/2$ just to the left of C.
15.27 (a) $Pa^3(L-a)/6EIL \uparrow$. (b) $Pa^2(3L-a)/6EIL \nearrow$.
15.28 (a) $PL^3/486EI \uparrow$. (b) $PL^2/81EI \searrow$.
15.29 (a) $wL^4/128EI \downarrow$. (b) $wL^3/72EI \searrow$.
15.30 (a) $19Pa^3/6EI \downarrow$. (b) $5Pa^2/2EI \searrow$.
15.31 $3PL^2/4EI \nearrow$, $13PL^3/24EI \downarrow$.
15.32 $Pa(2L-a)/2EI \searrow$; $Pa(3L^2 - 3aL + a^2)/6EI \uparrow$.
15.35 7.91×10^{-3} rad \nearrow ; 0.340 in. \downarrow .
15.36 6.98×10^{-3} rad \nearrow ; 0.1571 in. \downarrow .
15.37 (a) 0.601×10^{-3} rad \searrow . (b) 3.67 mm \downarrow .
15.39 (a) $41wL/128 \uparrow$. (b) $23wL/128 \uparrow$; $7wL^2/128 \curvearrowright$.
15.40 (a) $4P/3 \uparrow$; $PL/3 \curvearrowright$. (b) $2P/3 \uparrow$.
15.42 $R_A = 7P/32 \uparrow$; $R_C = 33P/16 \uparrow$; $R_E = 23P/32 \uparrow$.
15.43 $13wL/32 \uparrow$, $11wL^2/192 \curvearrowright$.
15.45 (a) 5.06×10^{-3} rad \searrow . (b) 47.7×10^{-3} in. \downarrow .
15.46 121.5 N/m.
15.48 (a) 0.00937 mm \downarrow . (b) 229 N \uparrow .
15.49 9.31 mm \downarrow .
15.50 0.278 in. \downarrow .
15.52 (a) 0.472L; 0.0940M₀L²/EI. (b) 4.07 m.
15.54 (a) $y = w_0(x^6 - 15L^2x^4 + 25L^3x^3 - 11L^5x)/360EIL^2$.
 (b) $11w_0L^3/360EI \searrow$. (c) $0.00916w_0L^4/EI \downarrow$.
15.55 4.00 kips.
15.56 $R_A = 9w_0L/640 \uparrow$; $M_{\text{mid}} = 0.00814w_0L^2$; $M_B = -0.0276w_0L^2$.
15.57 $PL^2/EI \nearrow$, $17PL^3/24EI \downarrow$.
15.59 6.32×10^{-3} rad \searrow ; 5.55 mm \downarrow .
15.60 $R_A = M_0/2L \uparrow$; $R_B = 5M_0/2L \uparrow$; $R_C = 3M_0/L \downarrow$.
15.61 (a) 10.86 kN \uparrow ; 1.942 kN·m \curvearrowright .
 (b) 1.144 kN \uparrow ; 0.286 kN·m \curvearrowright .

CHAPTER 15

- 15.1** (a) $y = -Px^2(3L-x)/6EI$. (b) $PL^3/3EI \downarrow$. (c) $PL^2/2EI \searrow$.
15.2 (a) $y = M_0(L-x)^2/2EI$. (b) $M_0L^2/2EI \uparrow$. (c) $M_0L/EI \searrow$.

CHAPTER 16

- 16.1** kL .
16.2 K/L .
16.3 $kL/4$.
16.4 K/L .
16.5 120.0 kips.
16.7 8.37 lb.
16.9 (a) 6.25%. (b) 12.04 kips.
16.10 (a) 7.48 mm. (b) 58.8 kN for round, 84.8 kN for square.
16.12 0.471.
16.13 168.4 kN.
16.14 69.6 kips.
16.16 (a) 93.0 kN. (b) 448 kN.
16.17 4.00 kN.
16.18 2.77 kN.
16.20 (a) $L_{BC} = 4.20$ ft; $L_{CD} = 1.050$ ft. (b) 4.21 kips.
16.22 657 mm.
16.23 29.5 kips
16.24 (a) 2.78. (b) $d_1 = 0.800$ in., $d_2 = 1.131$ in., $d_3 = 0.566$ in.,
 $d_4 = 0.669$ in., $d_5 = 0.800$ in.
16.25 (a) 59.6 kips. (b) 31.9 kips.
16.26 414 kN.
16.27 (a) 220 kN. (b) 841 kN.
16.28 (a) 86.6 kips. (b) 88.1 kips.
16.31 (a) 251 mm. (b) 363 mm. (c) 689 mm.
16.32 79.3 kips.
16.33 1596 kN.
16.34 899 kN.
16.36 173.5 kips.
16.37 (a) 66.3 kN. (b) 243 kN.
16.39 6.53 in.
16.40 (a) 4 boards. (b) 3 boards.
16.41 1.591 in.
16.42 9.00 mm.
16.44 $W250 \times 67$.
16.46 $3/8$ in.
16.47 $1/4$ in.
16.48 $L3-1/2 \times 2-1/2 \times 3/8$.
16.49 70.2 kips.
16.50 $ka^2/2I$.
16.52 0.384 in.
16.53 $\pi^2 b^2/12L^2 \alpha$.
16.56 5.37 kN.
16.58 124.6 kips.
16.59 (a) 1529 kN. (b) 638 kN.
16.60 $W200 \times 46.1$.