Appendix G: Answers to Even-Numbered Problems

Unless stated otherwise, x components are positive to the right, y components are positive upward, and counterclockwise moments are positive.

A. Bedford, K. M. Liechti, *Mechanics of Materials*,
https://doi.org/10.1007/978-3-030-22082-2

1.2	$A_x = 0$, $A_y = 2.5$ kN, $B = 27.5$ kN.
1.4	$A = 35$ lb, $B = 25$ lb.
1.6	$P = 0$, $V = -144$ kN, $M = -288$ kN-m.
1.8	$\mathbf{R} = 173\mathbf{i} + 100\mathbf{j}$ (N), $\mathbf{M} = -396\mathbf{k}$ (N-m).
1.10	$m = 52.3$ kg.
1.12	84.9 kN (T)
1.14	$F = 2.48$ kip.
1.16	Member CE, 4.72 kN (T). Member DE, 3.92 kN (C)
1.18	AC : 150 kN (T), BC : 90.1 kN (T), BD : 225 kN (C).
1.20	$C_x = 0$, $C_y = F$, $D_x = 0$, $D_y = -2F$, $E = F$.
1.22	3876 lb. (compression)
1.24	6000 lb. (tension)
1.26	1.70 kN (tension)
1.28	1.65 kN (compression)
1.30	$A_x = 15$ kN, $A_y = -8$ kN, $E_x = -15$ kN, $E_y = 14$ kN.
1.32	$\overline{x} = 667$ mm, $\overline{y} = 133$ mm.
1.34	$\overline{x} = 90.3$ mm, $\overline{y} = 59.4$ mm.
1.36	Distance = 3.28 ft.
1.38	**(a)** $A_x = 0$, $A_y = 80.7$ N, $B = 210$ N. **(b)** $w = 223$ N/m.
1.40	$A_x = 0$, $A_y = 159$ lb, $B = 169$ lb.
1.42	$R_x = 0$, $R_y = -913$ N, $M_R = 1970$ N-m clockwise
1.46	$A = c_0/2$, $B_x = 0$, $B_y = -c_0/2$.
2.2	**(a)** $A' = 0.00354$ m^2. **(b)** $\sigma_{\text{av}} = 1.20\text{E}6$ Pa, $\tau_{\text{av}} = 1.20\text{E}6$ Pa.
2.4	**(a)** $\sigma_{\text{av}} = 318$ psi. **(b)** $\sigma_{\text{av}} = -637$ psi.
2.6	$P = 8.18$ kN, $\tau_{\text{av}} = -168$ kPa.
2.8	$\sigma_{\text{av}} = 267$ psi, $\lvert\tau_{\text{av}}\rvert = 533$ psi.
2.10	$\sigma_{\text{av}} = 20,400$ psi.

2.12	$\sigma_{av} = 74.6x$ kPa. (x in meters)
2.14	$\sigma_{av} = 22.8$ psi, $\lvert\tau_{av}\rvert = 62.6$ psi.
2.16	$\sigma_{av} = 200$ kPa, $\lvert\tau_{av}\rvert = 83.3$ kPa.
2.18	$\sigma_{av} = 5.96$ MPa (864 psi).
2.20	**(a)** $\sigma_{av} = 9.42$ MPa. **(b)** $\sigma_{av} = 13.3$ MPa.
2.22	**(a)** $\tau_{av} = P/A$. **(b)** $\tau_{av} = P/(2A)$.
2.24	$\tau_{av} = 41.7$ MPa.
2.26	$\sigma_{av} = 102$ ksf.
2.28	$\lvert\tau_{av}\rvert = 3.60$ ksi.
2.30	$\sigma_{av} = 31.1$ MPa, $\lvert\tau_{av}\rvert = 9.17$ MPa.
2.32	$\sigma_{av} = -129$ psi, $\lvert\tau_{av}\rvert = 153$ psi.
2.34	$\tau_{av} = 18.75$ psi.
2.36	$\tau_{av} = 21.2$ MPa.
2.38	$\tau_{av} = F/(bt)$.
2.40	$\tau_{av} = 1.82$ psi.
2.42	$\sigma = 50$ kPa.
2.44	$\sigma = 2860$ psi.
2.46	**(a)** $70\mathbf{i} - 10\mathbf{j} - 5\mathbf{k}$ (kN). **(b)** $-70\mathbf{i} + 10\mathbf{j} + 5\mathbf{k}$ (kN).
2.48	$\sigma_{av} = 0.533$ MPa.
2.50	$\mathbf{t}_{av} = 1.955\mathbf{i} + 0.090\mathbf{j} + 1.060\mathbf{k}$ (MPa).
2.52	$a = 111$ lb/in^3.
2.54	$dL' = 1.15\,dL$.
2.56	$L' = 6.24$ in.
2.58	$L' = 0.2113$ m.
2.60	$\varepsilon = 0.00625$.
2.62	$\delta = -3.60$ mm.
2.64	$\delta = 0.028$ in.

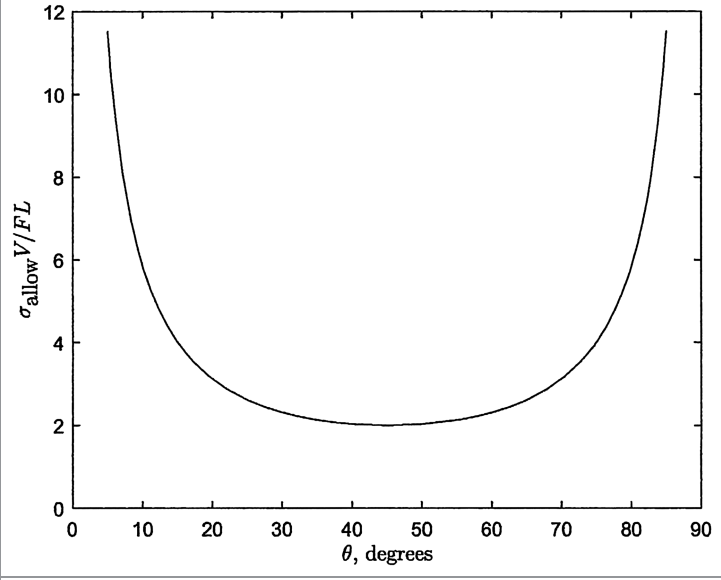
(continued)

2.66	$\varepsilon_{AB} = 0.1062$.
2.68	$\varepsilon = 0.00454$.
2.70	$\varepsilon = 0.0075$.
2.72	$\varepsilon_1 = 0.000333$, $\varepsilon_2 = -0.008333$.
2.74	$\gamma_{12} = 0.698$.
2.76	$\gamma_{12} = 0.0870$.
2.78	$\gamma_{12} = -0.234$.
2.80	$\varepsilon_x = 0.00296$, $\varepsilon_y = 0.00204$, $\varepsilon_z = 0.00204$, $\gamma_{xy} = -0.00370$, $\gamma_{yz} = 0$, $\gamma_{xz} = 0$.
2.82	$\sigma_{\text{av}} = 0$, $\tau_{\text{av}} = 398$ psi.
2.84	$\sigma_{\text{av}} = 320$ psi.
2.86	$\sigma_{\text{av}} = 200$ kPa, $\lvert\tau_{\text{av}}\rvert = 0$.
2.88	$\sigma_{\text{av}} = -750$ kPa.
2.90	$\sigma_{\text{av}} = -500$ kPa, $\tau_{\text{av}} = 267$ kPa.
2.92	$\tau_{\text{av}} = 92.9$ MPa.
2.94	$\tau_{\text{av}} = 2.32$ MPa.
2.96	$L' = 0.2008$ m.
2.98	$\delta = -0.028$ in.
2.100	$\varepsilon = 0.02$.
2.102	$\varepsilon = 0.476$.
3.2	(a) $\sigma_{AB} = 2.83$ MPa. (b) $\sigma_{BC} = 0.943$ MPa.
3.4	$\sigma = 568$ kPa.
3.6	$\sigma = 4.5$ ksi.
3.8	$\sigma_{BC} = -578$ MPa, $\sigma_{DG} = 1440$ MPa.
3.10	$\sigma = -10.3$ MPa.
3.12	$\sigma = 4.90$ ksi.
3.16	$\sigma_{BC} = 106$ MPa.
3.18	$F = 2170$ N.
3.20	$\sigma_\theta = 1.75$ ksi, $\tau_\theta = -4.82$ ksi.

3.22	$\theta = 50.2^{\circ}$, $P = 61.0$ kN.
3.24	**(a)** $\lvert\tau_\theta\rvert = 0$. **(b)** $\lvert\tau_\theta\rvert = 18.2$ MPa. **(c)** $\lvert\tau_\theta\rvert = 27.9$ MPa.
3.26	$F = 5200$ lb.
3.28	$F = 173$ kN.
3.30	$\sigma_{AB} = -1900$ psi.
3.32	$\sigma_3 = -63.1$ MPa.
3.34	10.02 in.
3.36	$\sigma = -0.7$ GPa.
3.38	$E = 76.4$ GPa, $\nu = 0.351$.
3.40	57.1 kip
3.42	$\delta_{AB} = 0.107$ in, $\delta_{AC} = -0.0571$ in.
3.44	$x = b/(1 + E_{BC}L_{DG}/E_{DG}L_{BC})$.
3.46	0.01 in.
3.48	1.95° clockwise
3.50	$\delta_{BE} = 0.0411$ in.
3.52	$\delta_{AB} = 5.28$ mm, $\delta_{AC} = -3.96$ mm.
3.54	$\delta_{BC} = 0.845$ mm, $\delta_{BD} = 0.602$ mm.
3.56	-0.0199 mm.
3.60	$\sigma = 2F/(3A)$.
3.62	$\sigma_{\text{rod}} = -87.0$ MPa, $\sigma_{\text{sleeve}} = -16.0$ MPa.
3.64	$\sigma_{BC} = -7.16$ MPa.
3.66	$F_1 = 76.2$ kN.
3.68	$b = 0.0681$ in.
3.70	$\sigma_{AB} = -F\cos^2\theta/[A(1 + \cos^3\theta)]$, $\sigma_{AC} = -F/[A(1 + \cos^3\theta)]$.
3.72	310 kN
3.74	$h = 2.95$ mm.
3.76	$\sigma_{BC} = -72.1$ MPa, $\sigma_{DG} = 126$ MPa, $\sigma_{HI} = 390$ MPa.

(continued)

3.78	9.92 kN
3.80	23.5 kN
3.82	0.268 mm to the left, 0.247 mm upward
3.84	$\delta = 0.0116$ in.
3.86	$\delta = 0.392$ mm.
3.88	$\sigma_L = 30.6$ ksi.
3.90	$\delta = 0.127$ mm.
3.92	$\delta = 6.13$ mm.
3.94	$\delta = 0.0588$ m.
3.96	$\delta = 0.0682$ m.
3.98	$x = 1.26$ m, displacement $= 0.101$ mm.
3.100	$\sigma_A = 57.6$ ksi.
3.102	0.00137 mm
3.104	$\delta = -F/\pi Ed \tan^2 \alpha$.
3.106	$\delta = 0.0131$ mm.
3.108	200.132 mm.
3.110	30.024 mm
3.112	$\sigma = 0$.
3.114	**(a, b)** $\delta = 0.0111$ in.
3.116	134 °F
3.118	$\sigma = -7470$ psi.
3.120	$\sigma_A = -16.8$ MPa, $\sigma_B = -67.2$ MPa.
3.122	$\sigma_{\text{sleeve}} = -557$ MPa.
3.124	16,000 lb. downward
3.126	0.369 in. to the right, 0.184 in. upward
3.128	1.20 mm to the left, 19.01 mm downward
3.130	$\sigma_{AB} = \sigma_{AD} = 46.3$ MPa, $\sigma_{AC} = 79.8$ MPa.
3.132	$\sigma_{AB} = -96.0$ MPa, $\sigma_{AC} = -109$ MPa.

3.134	0.916 mm
3.136	Either 2014-T6 or 7075-T6
3.138	ASTM-A514
3.140	3.70 in^2.
3.142	
3.144	2014-T6 or 7075-T6
3.150	$A = 0.00912$ in^2.
3.152	$A_3 = 1850$ mm^2.
3.154	$\sigma_{AB} = 2.31$ MPa.
3.156	$\sigma_{AB} = 488$ MPa, $\sigma_{AC} = 345$ MPa.

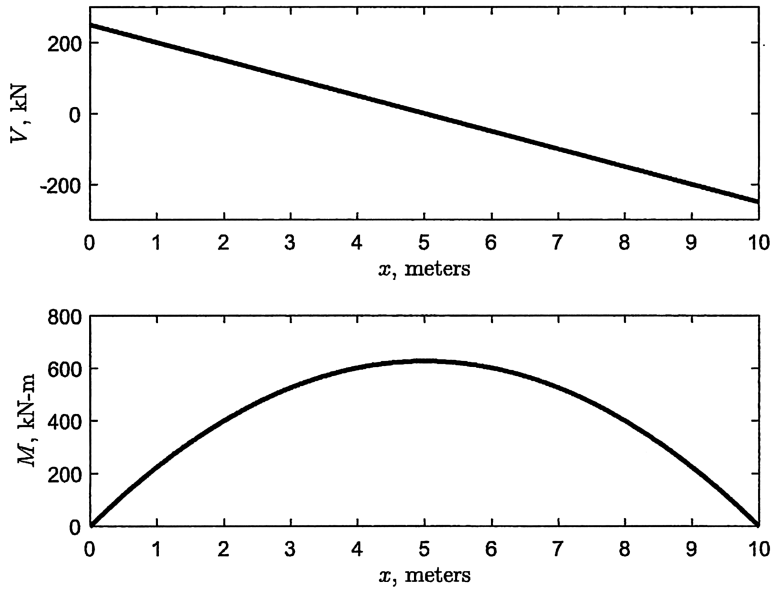
(continued)

3.158	$\sigma = 1.12$ MPa.
3.160	$\sigma_\theta = 120.0$ ksi, $\lvert \tau_\theta \rvert = 69.3$ ksi.
3.162	$D' = 0.7495$ in.
3.164	$\varepsilon_{AB} = 0.000349$, $\varepsilon_{CD} = 0.000698$, $\varepsilon_{EF} = 0.001047$.
3.166	$\delta_{AB} = 0.292$ in, $\delta_{AC} = -0.137$ in.
3.168	A : 400E6 N (tension); B : 400E6 N (compression).
3.170	40 °C
3.172	$\sigma_{AB} = 81.7$ MPa, $\sigma_{AC} = -35.5$ MPa, $\sigma_{AD} = -82.6$ MPa.
4.2	$\beta = 89.0^\circ$.
4.4	$\beta = 89.9^\circ$.
4.6	$G = 75.8$ GPa.
4.8	$\sigma_\theta = 10.4$ MPa, $\lvert \tau_\theta \rvert = 6$ MPa.
4.10	$\tau = 16.2$ MPa.
4.12	**(a)** $\sigma_\theta = -17.3$ ksi, $\lvert \tau_\theta \rvert = 10$ ksi. **(b)** 20 ksi
4.14	$\tau = 3.97$ MPa, $\theta = 20.5^\circ$.
4.16	$J = 23.6$ in^4.
4.18	$\lvert \tau \rvert = 17.0$ MPa.
4.20	$\lvert\tau\rvert = 19.9$ MPa.
4.22	$\lvert\tau\rvert = 11.7$ MPa.
4.24	$\lvert\tau\rvert = 31.8$ MPa.
4.26	$R_o = 69.5$ mm.
4.28	$\phi = 3.96$ rad (227°).
4.30	$\phi = 0.000382$ rad (0.0219°)
4.32	**(a)** $\lvert \tau \rvert = 637$ psi. **(b)** 0.00110 rad (0.0629°).
4.34	$\lvert\tau_{AB}\rvert = 19.9$ ksi, $\lvert\tau_{BC}\rvert = 8.49$ ksi.

4.36	$\|\tau_{AB}\| = 30.9$ MPa, $\|\tau_{BC}\| = 61.8$ MPa, $\|\tau_{CD}\| = 124$ MPa.
4.38	$\|\tau_{AB}\| = 37.7$ MPa, $\|\tau_{CD}\| = 28.3$ MPa.
4.40	$r_C = 108$ mm.
4.42	$\|T_0\| = 13.7$ in-kip.
4.44	$\|T_{AB}\| = 1110$ N-m, $\|T_{BC}\| = 92.3$ N-m.
4.46	$\phi = 0.0107$ rad (0.614°).
4.48	$\|\phi_A\| = 1.82^{\circ}$, $\|\phi_B\| = 0.180^{\circ}$.
4.50	656 MPa
4.52	$\|\tau\| = 21.9$ MPa.
4.54	$\|\tau\| = 17.9$ ksi.
4.56	$\|\tau\| = 2.83$ ksi.
4.58	$a = 0.251$ m^{-1}.
4.60	$T = 6.19$ N-m.
4.62	102 N-m
4.64	$\|\tau\| = 40.7$ MPa.
4.66	$c_0 = 7200$ in-lb/in. , $\|\tau\| = 18.7$ ksi.
4.70	$\|T_{\text{left}}\| = 5c_0L/192$, $\|T_{\text{right}}\| = c_0L/64$.
4.72	$T = 6.49$ kN-m.
4.74	$\phi = 117^{\circ}$.
4.76	$r_Y = 0.553$ in, $\phi = 74.6^{\circ}$.
4.78	$T = 15.5$ kN-m.
4.80	$\phi = 142^{\circ}$.
4.84	$\phi = 0.00937$ rad (0.537°).
4.86	**(a)** $\|\tau\| = 27.8$ MPa. **(b)** $\|\tau\| = 19.4$ MPa.
4.88	$\|\tau\| = 30.4$ MPa.
4.90	$\phi = 0.975^{\circ}$.

(continued)

4.92	$\|\tau\| = 5540$ psi.
4.94	$t = 0.0802$ in, $\phi = 1.95^\circ$.
4.96	$\phi = 4.27^\circ$.
4.98	$\|\tau\| = 68.5$ MPa.
4.100	**(a)** $\|\tau\| = 1591.5$ lb/in^2. **(b)** $\|\tau\| = 1590.6$ lb/in^2.
4.102	$\|\tau_{\max}\| = 31.8$ MPa.
4.104	7075-T6 aluminum alloy
4.116	$G = 1.22$E7 psi.
4.118	$\gamma = 0.00346$.
4.120	$\phi = 0.000668$ rad (0.0383°).
4.122	$T = 1.99$ kN-m.
4.124	$\sigma_\theta = 20.5$ kPa, $\|\tau_\theta\| = 24.4$ kPa.
4.126	$\|\tau_{AB}\| = 8.13$ ksi, $\|\tau_{BC}\| = 4.06$ ksi.
4.128	$\|\tau\| = 325$ MPa.
5.2	$P_C = 0$, $V_C = -0.5$ kN, $M_C = 0.5$ kN-m.
5.4	$P_B = 0$, $V_B = 2$ kN, $M_B = -2$ kN-m.
5.6	**(b)** $A_x = 0$, $A_y = 0$, $B_y = 0$. **(c)** $P_C = 0$, $V_C = 0$, $M_C = -4$ kN-m.
5.8	**(a)** $P_A = 0$, $V_A = 4$ kN, $M_A = 4$ kN-m. **(b)** $P_A = 0$, $V_A = 2$ kN, $M_A = 3$ kN-m.
5.10	$P_A = 0$, $V_A = 16.7$ lb, $M_A = 575$ in-lb.
5.12	$P_A = 0$, $V_A = -475$ lb, $M_A = -1275$ ft-lb.
5.14	$P_A = 0$, $V_A = 4.8$ kN, $M_A = 13.6$ kN-m.
5.16	$P_C = 0$, $V_C = -3.7$ kN, $M_C = 14.1$ kN-m.
5.18	$P_B = 10.7$ kN, $V_B = -12$ kN, $M_B = 1.4$ kN-m.
5.20	$P_B = 90$ kN, $V_B = -40$ kN, $M_B = -20$ kN-m.

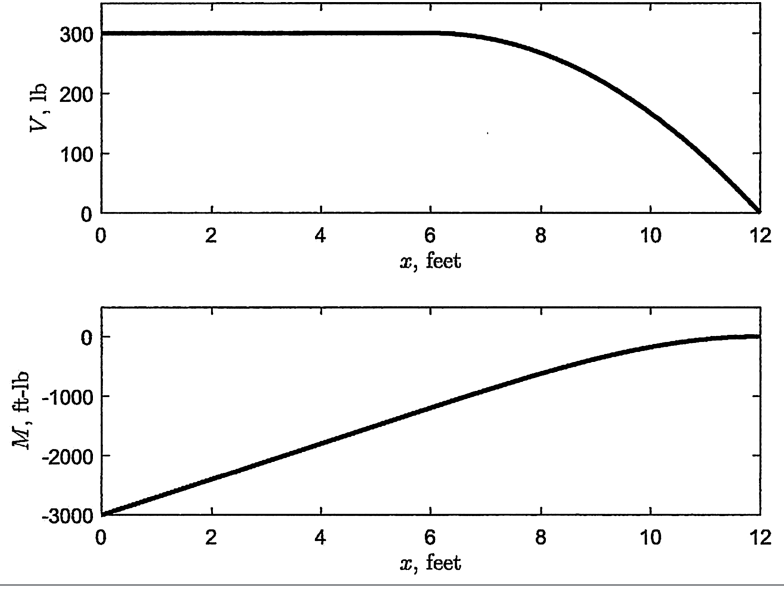
5.22	**(a)** $P = 0$, $V = -50x + 250$ kN, $M = -25x^2 + 250x$ kN-m. **(c)** 
5.24	**(a)** $P = 0$, $V = 1080 - 10x^2$ lb, $M = 1080x - (10/3)x^3$ ft-lb. **(c)** $M = 7480$ ft-lb at $x = 10.4$ ft.
5.26	$P = 0$, $V = -F$, $M = -Fx$.
5.28	$P = 0$, $V = -20$ N, $M = -20x$ N-m.
5.30	$P = 0$, $V = -400 - (25/3)x^2$ lb, $M = -400x - (25/9)x^3$ ft-lb.

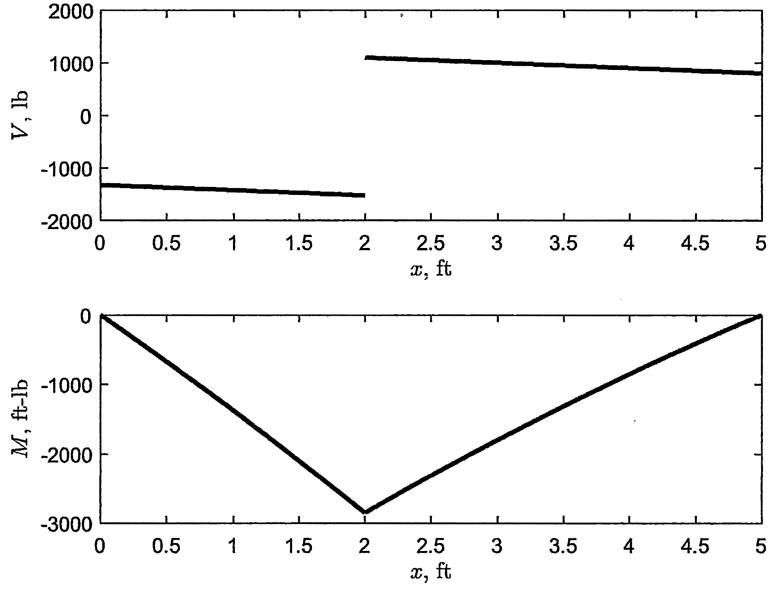
(continued)

5.32

(a) $0 < x < 6$ ft: $P = 0$, $V = 300$ lb, $M = 300x - 3000$ ft-lb. $6 < x < 12$ ft: $P = 0$, $V = 300 - (25/3)(x - 6)^2$ lb, $M = -3000 + 300x - (25/9)(x - 6)^3$ ft-lb.

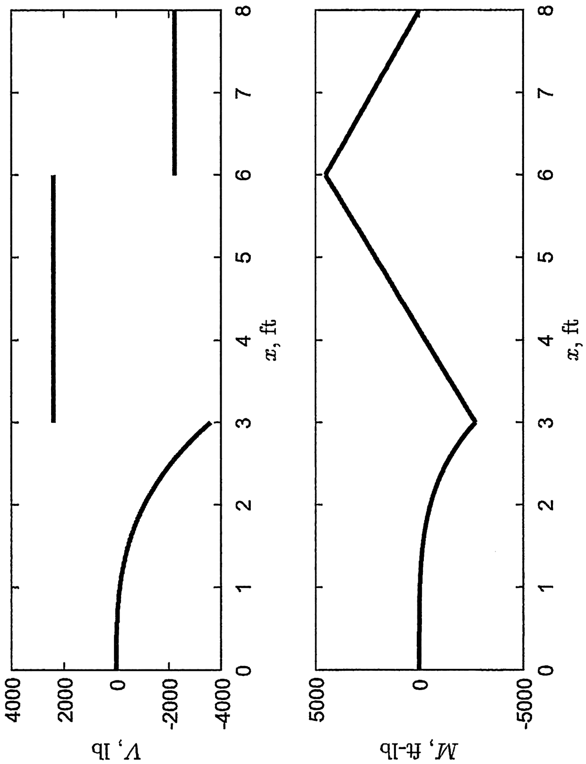
(b)

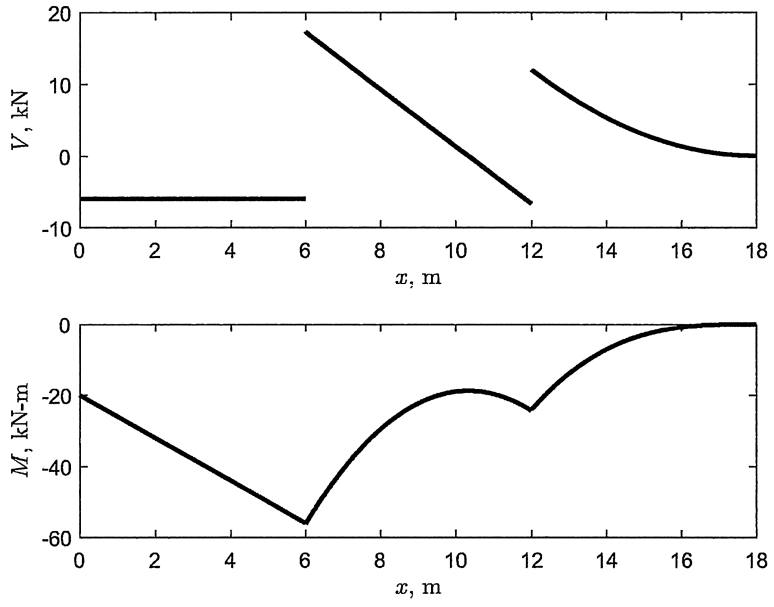


5.34	$M = 578$ in-lb at $x = 9.33$ in.
5.36	

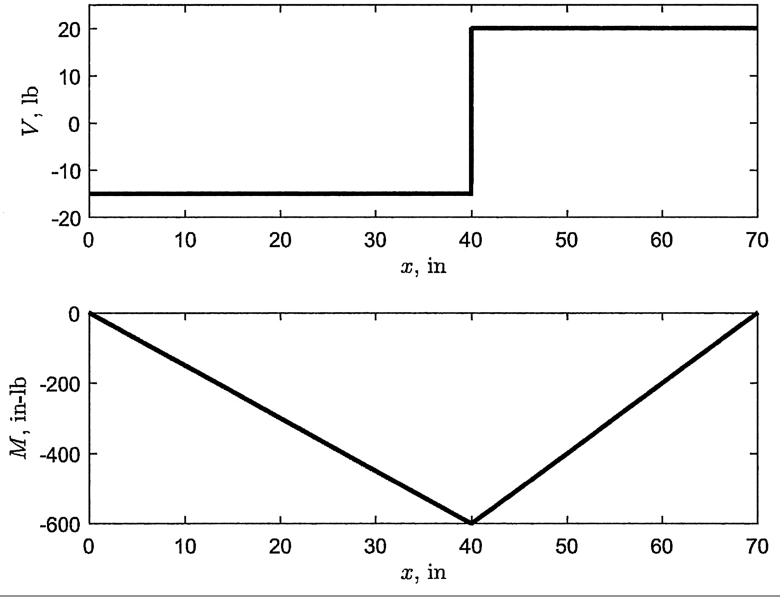
(continued)

5.38



5.40	
5.42	$V = -31.3 + 10x + 0.25x^2 - 0.2x^3$ kN.
5.44	$V = -w_0(x - x^2/2L)$, $M = -w_0(x^2/2 - x^3/6L)$.
5.46	$V = F$, $M = Fx$.
5.48	$V = w_0L/6 - w_0x^2/2L$, $M = (Lx - x^3/L)w_0/6$.
5.50	$V = w(L/2 - x)$, $M = -(w/2)(L^2/6 - Lx + x^2)$.
5.54	$0 < x < 2$ m: $P = 0$, $V = x$ kN, $M = x^2/2$ kN-m. $2 < x < 5$ m: $P = 0$, $V = -4 + x$ kN, $M = 8 - 4x + x^2/2$ kN-m. $5 < x < 6$ m: $P = 0$, $V = -6 + x$ kN, $M = 18 - 6x + x^2/2$ kN-m.

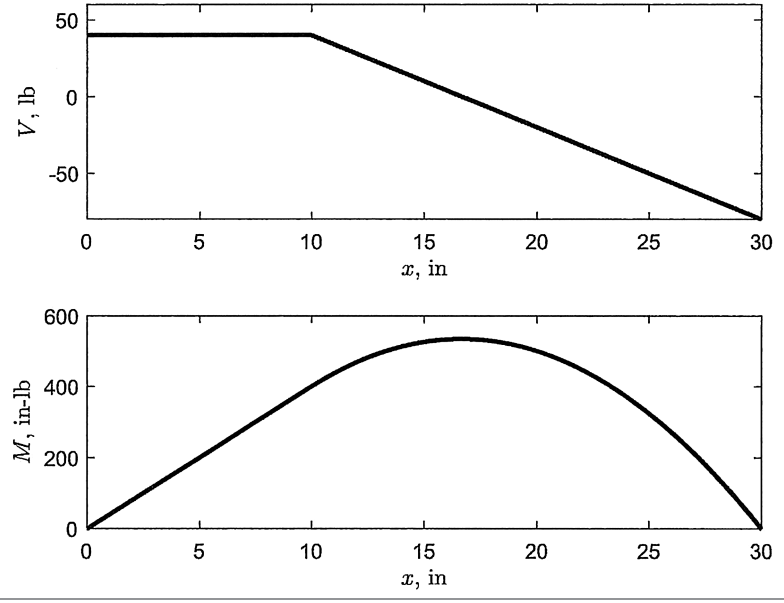
(continued)

5.58	**(a)** $V = -15\langle x\rangle^0 + 35\langle x - 40 \text{ in}\rangle^0 - 20\langle x - 70 \text{ in}\rangle^0$ lb, $M = -15\langle x\rangle + 35\langle x - 40 \text{ in}\rangle - 20\langle x - 70 \text{ in}\rangle$ in-lb. **(b)** 
5.60	$V = 2F\langle x\rangle^0 - F\langle x - \frac{L}{3}\rangle^0 - 4F\langle x - \frac{2L}{3}\rangle^0 + 3F\langle x - L\rangle^0$, $M = 2F\langle x\rangle - F\langle x - \frac{L}{3}\rangle - 4F\langle x - \frac{2L}{3}\rangle + 3F\langle x - L\rangle$.

5.62

(a) $V = 40\langle x\rangle^0 - 6\langle x - 10\text{ in}\rangle + 80\langle x - 30\text{ in}\rangle^0$ lb,
$M = 40\langle x\rangle - 3\langle x - 10\text{ in}\rangle^2 + 80\langle x - 30\text{ in}\rangle$ in-lb.

(b)

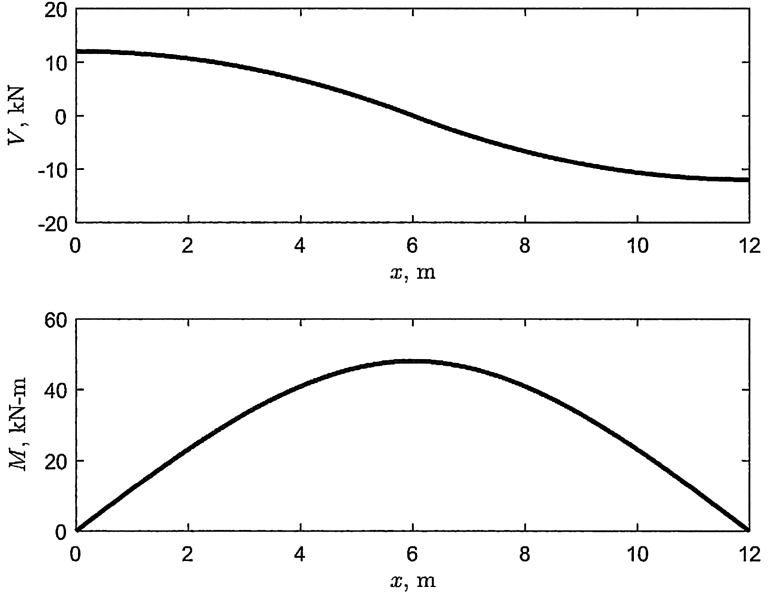


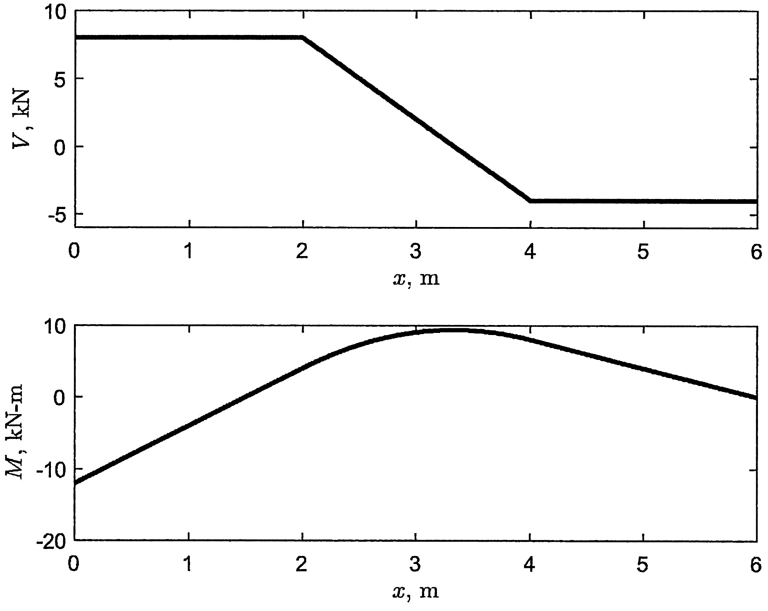
(continued)

5.64

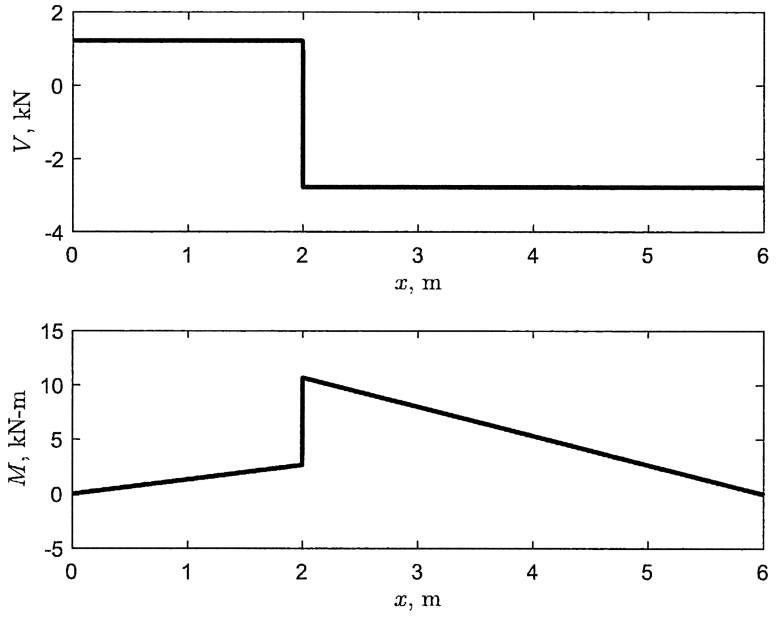
(a) $V = 12\langle x\rangle^0 + 12\langle x - 12\text{ m}\rangle^0 - \frac{1}{3}\langle x\rangle^2 + \frac{2}{3}\langle x - 6\text{ m}\rangle^2$ kN,
$M = 12\langle x\rangle + 12\langle x - 12\text{ m}\rangle - \frac{1}{9}\langle x\rangle^3 + \frac{2}{9}\langle x - 6\text{ m}\rangle^3$ kN-m.

(b)



5.66	**(a)** $V = -12\langle x\rangle^{-1} + 8\langle x\rangle^{0} + 4\langle x - 6\text{ m}\rangle^{0} - 6\langle x - 2\text{ m}\rangle + 6\langle x - 4\text{ m}\rangle$ kN, $M = -12\langle x\rangle^{0} + 8\langle x\rangle + 4\langle x - 6\text{ m}\rangle - 3\langle x - 2\text{ m}\rangle^{2} + 3\langle x - 4\text{ m}\rangle^{2}$ kN-m. **(b)** 
5.68	$P_C = 0$, $V_C = -2$ kN, $M_C = -4$ kN-m.
5.70	$P_A = 0$, $V_A = 225$ kN, $M_A = -375$ kN-m.
5.72	No. The resulting maximum bending moment magnitude is 8 kN-m

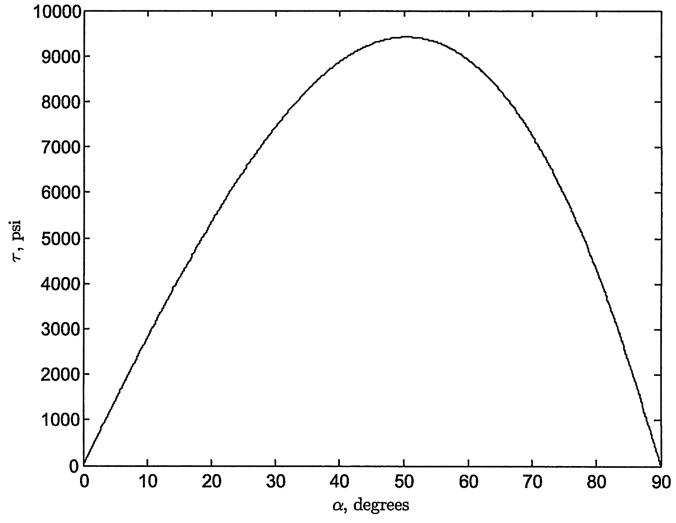
(continued)

5.74	
6.2	(**a**) $\sigma_x = -9380$ psi. (**b**) 18, 800 psi.
6.4	$M = 492$ kN-m.
6.6	$M = 177,000$ in-lb.
6.8	(**a**) $M = 22.1$ N-m. (**b**) $\sigma_{\max} = 8.28$ MPa.
6.10	(**a**) $\sigma_x = 129$ MPa. (**b**) $\sigma_x = 78.6$ MPa.
6.12	(**a**) $M = 2700$ N-m at $x = 2.25$ m. (**b**) 11.8 MPa.
6.14	(**a**) $\sigma_x = 13.1$ ksi. (**b**) $\sigma_x = 6.75$ ksi.

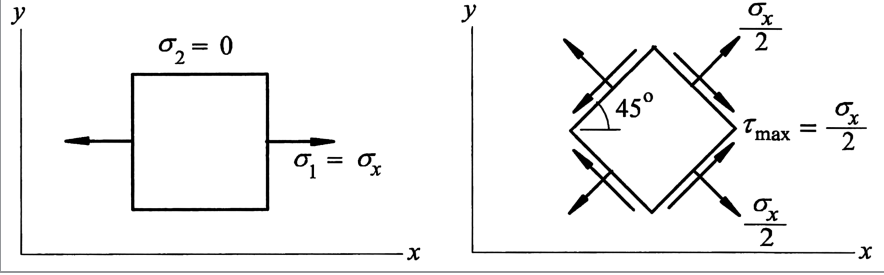
6.16	$\sigma_x = 1.24$ GPa.
6.18	FS $= 1.87$.
6.20	$h = 3.90$ in.
6.22	**(a)** FS $= 2.01$. **(b)** FS $= 4.69$.
6.28	W150X29.8
6.30	W6X16
6.32	Steel, 1520 psi; aluminum, 876 psi
6.34	$H = 0.02$ m.
6.36	$H = 2.8$ in.
6.38	$E_B = 216$ GPa.
6.40	**(a)** $\sigma_x = 26.3$ MPa. **(b)** $\sigma_x = 13.8$ MPa.
6.42	**(a)** $w_0 = 1320$ lb/in. **(b)** $w_0 = 2580$ lb/in.
6.44	$\sigma_x = 3.02$ MPa.
6.46	$d = 0.0274$ m.
6.48	**(a)** 640,000 in-lb. **(b)** 960,000 in-lb.
6.50	$w_0 = 50,\ 300$ N/m.
6.52	$x = \sqrt{12}$ m, $d = 0.0293$ m.
6.54	$w_0 = 22,\ 700$ N/m, $x = 0.6$ m.
6.56	$w_0 = 116$ lb/in, $x = 18$ in.
6.60	$M_{\mathrm{U}} = 11.0$ kN-m.
6.62	$\sigma_x = 31.3$ MPa.
6.64	$\sigma_x = -14$ MPa.
6.66	$\lvert \sigma_x \rvert = 9210$ psi.

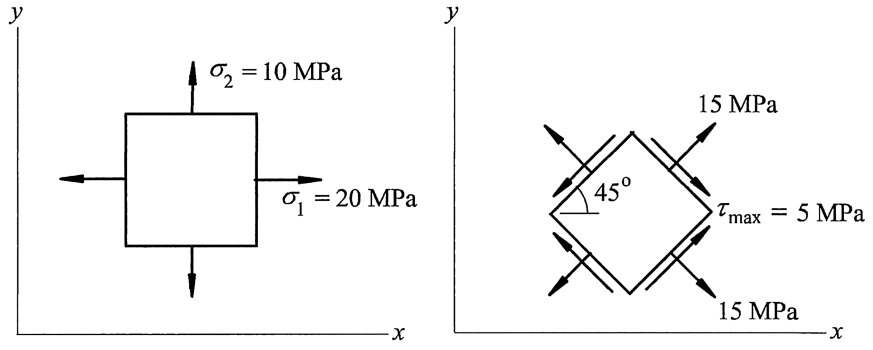
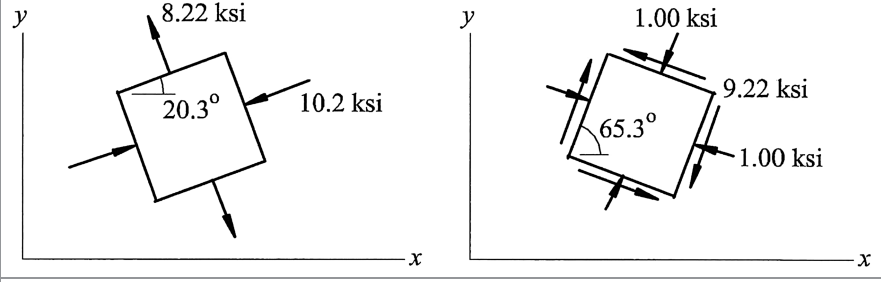
(continued)

6.68	$\mid \sigma_x \mid = 21,400$ psi.
6.70	$\mid \sigma_x \mid = 2.08$ MPa.
6.72	$\sigma_x = -18,300$ psi.
6.74	$\sigma_x = -48.6$ MPa.
6.76	**(a)** $\tau_{\text{av}} = 4.44$ MPa.. **(b)** $\tau_{\text{av}} = 2.78$ MPa.
6.78	$\tau_{\text{av}} = 576$ kPa at $x = 0$, $y' = 0$ and at $x = 8$ m, $y' = 0$.
6.80	**(a)** $\tau_{\text{av}} = -2810$ psi. **(b)** $\tau_{\text{av}} = -1230$ psi.
6.84	$\tau_{\text{av}} = 6.86$ MPa.
6.86	$y' = 1$ in, $\tau_{\text{av}} = 4170$ psi.
6.88	$\tau_{\text{av}} = 11.4$ MPa.
6.90	$\tau_{\text{av}} = 6.31$ MPa.
6.92	$\tau_{\text{av}} = 5.35$ MPa.
6.94	3 kN/bolt
6.96	13.1 kN/bolt
6.98	577 N/bolt
6.100	$\tau = 30.9$ MPa.
6.102	$\tau = 2250$ psi.
6.104	$\tau = 138\zeta$ MPa (ζin meters)

6.106	
6.108	$\tau = 2.65\alpha + 9.46 \sin \alpha$ MPa.
6.110	$e = 0.312$ m.
6.112	$e = 0.0332$ m.
6.114	$e = 7.54$ in.
6.116	$e = 0.0637$ m.
6.118	$e = 3.12$ in.
6.120	$e = 0.0394$ m.
6.122	$M = 16,000$ in-lb.
6.124	6.84 MPa.
6.126	$w_0 = 13.3$ kN/m.

(continued)

6.128	$w_0 = 9.32$ kN/m.
6.130	$x = 2.86$ m, $d = 50.7$ mm.
6.132	$\sigma_x = -4.11$ MPa.
6.134	**(a)** $\tau_{av} = -19.9$ MPa. **(b)** $\tau_{av} = -11.1$ MPa.
6.136	$\tau_{av} = 223$ psi.
7.2	**(a)** $\sigma_y = -4$ MPa. **(b)** $\lvert\tau\rvert = 3.35$ MPa.
7.4	**(a)** $\sigma_x = 360$ psi, $\sigma_y = -480$ psi, $\sigma_z = 0$, $\tau_{xy} = -640$ psi, $\tau_{xz} = 0$, $\tau_{yz} = 0$. **(b)** $\sigma_{x'} = -150$ psi, $\sigma_{y'} = 29.6$ psi, $\tau_{x'y'} = -760$ psi.
7.6	$\sigma_{x'} = 25$ ksi, $\sigma_{y'} = -25$ ksi, $\tau_{x'y'} = 0$.
7.8	$\sigma_x = 64.00$ MPa, $\sigma_y = 85.00$ MPa, $\tau_{xy} = 0.00$ MPa.
7.10	$\sigma_x = 38.8$ MPa, $\sigma_y = -22.8$ MPa, $\tau_{xy} = 14.3$ MPa.
7.12	$\sigma = -2.23$ ksi, $\lvert\tau\rvert = 1.60$ ksi.
7.14	$\sigma_{(a)} = -56.6$ MPa, $\sigma_{(b)} = -50.0$ MPa, $\sigma_{(c)} = -33.2$ MPa.
7.16	$\sigma = -7.86$ MPa, $\tau = 13.50$ MPa.
7.18	$\tau_{x'y'} = 4.90$ MPa, $\theta = 19.5^\circ$ or $\tau_{x'y'} = -4.90$ MPa, $\theta = 40.2^\circ$.
7.20	$\tau_{xy} = -78.4$ psi, $\tau_{x'y'} = -114$ psi.
7.24	$\sigma_1 = \sigma_x$, $\sigma_2 = 0$, $\tau_{max} = \lvert\sigma_x/2\rvert$. 

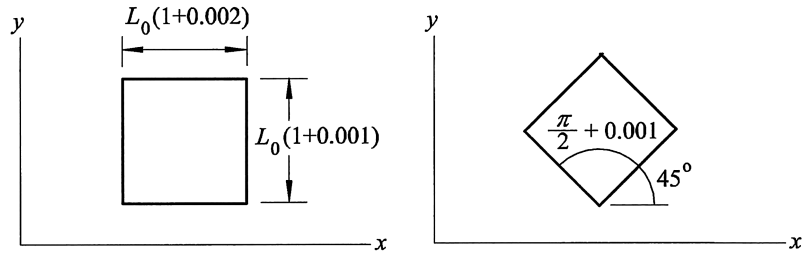
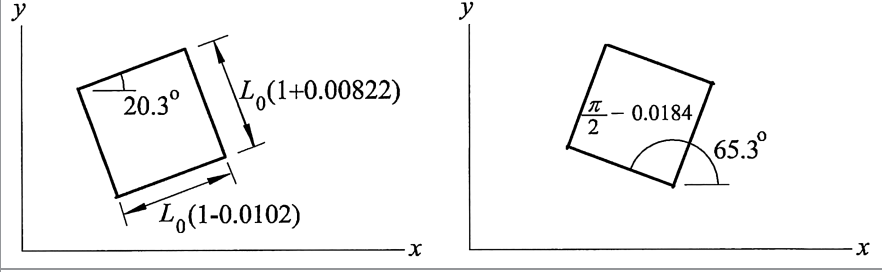
7.26	$\sigma_1 = 20$ MPa, $\sigma_2 = 10$ MPa, $\tau_{max} = 5$ MPa. 
7.28	$\sigma_1 = 8.22$ ksi, $\sigma_2 = -10.22$ ksi, $\tau_{max} = 9.22$ ksi. 
7.30	Absolute maximum shear stress = 10 MPa.
7.32	$\sigma_1 = 52.4$ MPa, $\sigma_2 = -32.4$ MPa, absolute maximum shear stress = 42.4 MPa.
7.36	No, the absolute maximum shear stress is 174 MPa
7.38	$\sigma_{x'} = 25$ ksi, $\sigma_{y'} = -25$ ksi, $\tau_{x'y'} = 0$.

(continued)

7.40	$\sigma_x = 64.0$ MPa, $\sigma_y = 85.0$ MPa, $\tau_{xy} = 0.00$ MPa.
7.42	$\theta = -20^\circ$.
7.44	$\sigma = 5.8$ MPa, $\lvert\tau\rvert = 4.9$ MPa.
7.46	$\sigma = 177$ psi, $\tau = -237$ psi.
7.48	See the answer to Problem 5–2.24
7.50	See the answer to Problem 5–2.26
7.52	$\sigma_1 = 52.5$ MPa, $\sigma_2 = -32.5$ MPa, $\tau_{\max} = 42.5$ MPa.
7.54	Absolute maximum shear stress = 6.6 ksi.
7.56	$\sigma_1 = 40.5$ ksi, $\sigma_2 = 0$, $\sigma_3 = -15.5$ ksi, $\tau_{\text{abs}} = 28.0$ ksi.
7.58	$\sigma_1 = 85.0$ MPa, $\sigma_2 = 65.0$ MPa, $\sigma_3 = 0$, $\tau_{\text{abs}} = 42.5$ MPa.
7.60	$\sigma_1 = \sigma_2 = 240$ MPa, $\sigma_3 = -120$ MPa, $\tau_{\text{abs}} = 180$ MPa.
7.62	$\sigma_1 = 409$ ksi, $\sigma_2 = 148$ ksi, $\sigma_3 = -257$ ksi, $\tau_{\max} = 333$ ksi.
7.64	(a), (b) $\sigma_1 = 8.22$ ksi, $\sigma_2 = 0$, $\sigma_3 = -10.2$ ksi.
7.68	$\sigma_1 = 46.4$ MPa, $\sigma_2 = -7.42$ MPa.
7.70	$\sigma_1 = 1700$ psi, $\sigma_2 = -5890$ psi, $\tau_{\max} = 3800$ psi.
7.72	$T = 1.38$ kN-m.
7.74	$\sigma_1 = 2860$ psi, $\sigma_2 = -318$ psi, $\tau_{\max} = 1590$ psi.
7.76	$\sigma_x = 1.11$ MPa, $\sigma_y = 0$, $\tau_{xy} = 0$.
7.78	$F = 1235$ N.
7.80	$\sigma = 142$ ksi, $\tau_{\text{abs}} = 71.3$ ksi.
7.82	$\sigma_{\text{h}} = 250$ MPa.
7.84	$\sigma_{\text{h}} = 15$ MPa, $\tau_{\text{abs}} = 7.65$ MPa.
7.86	$t = 6.02$ mm.
7.92	$\sigma = 7.10$ MPa, $\lvert\tau\rvert = 1.57$ MPa.
7.94	$\mathbf{t} = 2.67\,\mathbf{i} - 0.332\,\mathbf{j} + 3.00\,\mathbf{k}$ (ksi).
7.96	$\sigma = 6.86$ GPa, $\lvert\tau\rvert = 2.15$ GPa.
7.98	$\lvert\tau\rvert = 10.0$ MPa.
7.100	$\sigma = \sigma_1$, $\lvert\tau\rvert = 0$.

7.102	$\sigma = -353$ psi, $\lvert \tau \rvert = 44.5$ psi.
7.106	$\theta = -20.0^{\circ}$.
7.108	$\sigma = -353$ psi, $\tau = -44.5$ psi.
7.110	Absolute maximum shear stress = 6.54 ksi.
7.112	$\sigma = 3530$ psi, $\lvert \tau \rvert = 1290$ psi.
7.114	$\tau_{\text{abs}} = 250$ MPa.
7.116	$\sigma_x = 13.5$ MPa, $\sigma_y = 0$, $\tau_{xy} = 4.77$ MPa.
7.118	$\sigma_x = 375$ psi, $\sigma_y = 0$, $\tau_{xy} = 0$.
7.120	2.11E5 Pa.
8.2	$\varepsilon_x = -0.004$, $\varepsilon_z = 0.0015$, $\gamma_{xz} = 0.00244$.
8.4	$\gamma_{xy} = 0.000997$.
8.6	$\theta = -20.0^{\circ}$.
8.8	$\varepsilon_x = 0.00640$, $\varepsilon_y = 0.00850$, $\gamma_{xy} = 0$.
8.10	$\gamma_{x'y'} = 0.0098$, $\theta = 19.5^{\circ}$ or $\gamma_{x'y'} = -0.0098$, $\theta = 40.2^{\circ}$.
8.12	$PQ = 0.997$ mm.
8.14	$\gamma_{xy} = -0.00360$.
8.16	$\varepsilon_x = -0.00201$, $\varepsilon_y = 0.00811$, $\gamma_{xy} = -0.00250$.
8.18	1.57626 rad (90.313°)
8.20	$\varepsilon_a = 0.00232$, $\varepsilon_b = 0.00203$, $\varepsilon_c = 0.00475$.
8.22	$\varepsilon_x = 0.003$, $\varepsilon_y = -0.001$, $\gamma_{xy} = 0$.
8.24	$\varepsilon_d = -0.00605$.

(continued)

8.26	$\varepsilon_1 = 0.002$, $\varepsilon_2 = 0.001$, $\gamma_{max} = 0.001$. 
8.28	$\varepsilon_1 = 0.00822$, $\varepsilon_2 = -0.01022$, $\gamma_{max} = 0.01844$. 
8.30	$\varepsilon_1 = 0.00472$, $\varepsilon_2 = -0.00272$, $\gamma_{max} = 0.00743$.
8.32	Absolute maximum shear strain = 0.00314.
8.38	$\varepsilon_{x'} = 0.002$, $\varepsilon_{y'} = -0.002$, $\gamma_{x'y'} = 0$.
8.42	$\gamma_{x'y'} = 0.00255$, $\theta = 14^\circ$ or $\gamma_{x'y'} = -0.00255$, $\theta = 40^\circ$.
8.44	$\varepsilon_x = 0.0039$, $\varepsilon_y = -0.0059$, $\gamma_{xy} = 0.012$.
8.46	See the answer to Problem 8.26
8.48	See the answer to Problem 8.28

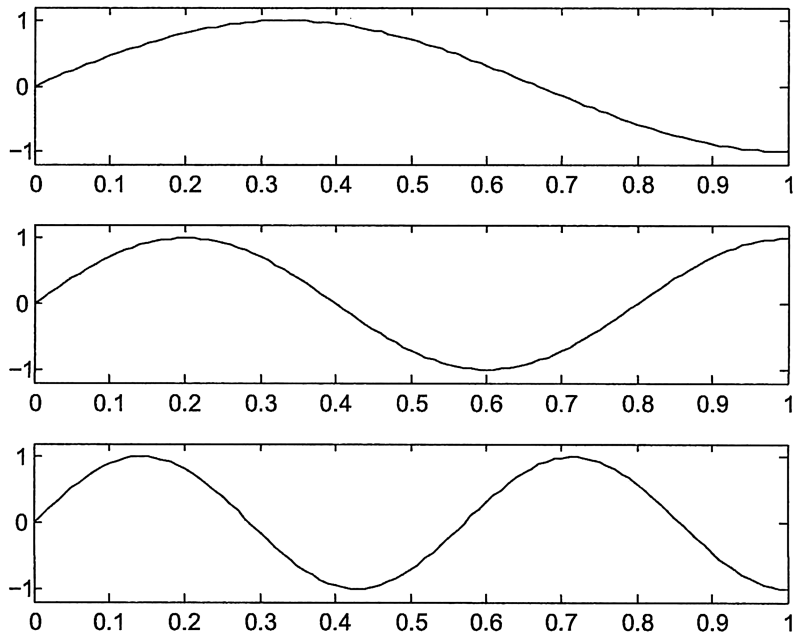
8.50	$\varepsilon_1 = 0.00368$, $\varepsilon_2 = -0.00608$, $\gamma_{\max} = 0.00977$.
8.52	$\sigma_x = 42.5$ MPa, $\sigma_y = -37.2$ MPa, $\sigma_z = -26.4$ MPa, $\tau_{xy} = 19.4$ MPa, $\tau_{yz} = -12.9$ MPa, $\tau_{xz} = 10.8$ MPa.
8.54	The required condition is that $\sigma_x + \sigma_y = 0$.
8.56	$\sigma_x = 63.8$ ksi, $\sigma_y = 83.3$ ksi, $\tau_{xy} = -93.6$ ksi.
8.58	(a) $\lambda = 46.2$ GPa, $\mu = 30.8$ GPa. (b) $K = 66.7$ GPa.
8.60	$\sigma_x = 34.2$ ksi, $\sigma_y = -33.5$ ksi, $\sigma_z = -44.8$ ksi, $\tau_{xy} = 56.4$ ksi, $\tau_{yz} = 0$, $\tau_{xz} = -56.4$ksi.
8.62	**(a)** $\varepsilon_x = \sigma_x/E$, $\varepsilon_y = \varepsilon_z = -\nu\sigma_x/E$, other strain components equal zero. **(b)** Volume $= (1 + \sigma_x/E)(1 - \nu\sigma_x/E)^2 LA$.
8.64	$\sigma_x = -55.5$ MPa, $\sigma_y = 104$ MPa, $\tau_{xy} = -94.3$ MPa.
8.66	$\sigma_x = 413$ MPa, $\sigma_y = 444$ MPa, $\tau_{xy} = -74.5$ MPa.
8.68	$\varepsilon_{x'} = 0.002$, $\varepsilon_{y'} = -0.002$, $\gamma_{x'y'} = 0$.
8.70	$\varepsilon_x = 0.00360$, $\varepsilon_y = 0.00320$, $\gamma_{xy} = -0.00358$.
8.72	$\varepsilon_x = -0.00160$, $\varepsilon_y = 0.00100$, $\gamma_{xy} = 0.00201$.
8.74	Absolute maximum shear strain $= 0.00559$.
8.76	$\sigma_x = -253$ MPa, $\sigma_y = 809$ MPa, $\tau_{xy} = -234$ MPa.
9.2	$\lvert v \rvert = 3.03$ mm.
9.4	$w = 19.3$ lb/in.
9.6	Displacement magnitude is 10.4 mm, slope is zero
9.8	$v = -0.558$ in, $v' = -0.0106$ rad.
9.10	$\lvert v \rvert = 28.2$ mm.
9.22	$\sigma_x = 5.04$ MPa.
9.24	$\lvert v \rvert = 3.02$ mm at $x = 1.63$ m.
9.26	$M_0 = 98.2$ kN-m.
9.28	$x = 36.4$ in.
9.30	$A_x = 0$, $A_y = -3M_0/(2L)$, $M_A = M_0/2$ clockwise, $B = 3M_0/(2L)$.
9.32	$A_x = 0$, $A_y = 9w_0L/40$, $M_A = 7w_0L^2/120$ counterclockwise, $B_y = 11w_0L/40$.

(continued)

9.34	$F_0 = 12,200$ lb, $M_0 = 294,000$ in-lb.
9.36	$x = 30.4$ in and 114 in.
9.38	$w_0 = 38.1$ kN/m.
9.40	$v = -w_0L^4/(768EI)$.
9.42	$v = 27.1$ mm.
9.44	$A = 2295$ lb, $M_A = 91,800$ in-lb counterclockwise.
9.46	$v = -(w_0/384EI)(16x^4 - 38Lx^3 + 29L^2x^2 - 8L^3x + L^4)$.
9.48	$v = (M_0/24LEI)[4\langle x\rangle^3 - 12L\langle x - L/2\rangle^2 - 4\langle x - L\rangle^3 - L^2\langle x\rangle]$.
9.50	$v = -10.1$ mm.
9.52	$v = -20.0$ mm.
9.54	$F = 3.83$ kN.
9.56	$v_B = -M_0L^2/2EI$.
9.58	$v_B = -w_0L^4/8EI$.
9.60	$v_B = -6.22$ mm.
9.62	$v = -(Fx^2/6EI)(3L - x) + M_0x^2/2EI$.
9.64	$v = -(w_0x/24EI)(L^3 - 2Lx^2 + x^3) + (Fx/48EI)(3L^2 - 4x^2)$.
9.66	$A = C = 1.5$ kN, $B = 5$ kN.
9.68	$v = -0.225$ in.
9.70	$v = -w_0L^4/(384EI)$.
9.72	$B = 2.71$ kN, $C = 1.71$ kN.
9.76	$A_x = 0$, $A_y = 11F/16$, $M_A = 3LF/16$ counterclockwise, $B_y = 5F/16$.
9.78	$v = -0.007L^3F/(EI)$.
9.80	$\lvert M_0\rvert = 72,700$ in-lb.

9.82	$v = -66.6$ mm.
10.2	$P = 965$ kip.
10.4	$P = 202$ kN.
10.6	$P = 806$ kN.
10.10	$R = 21.5$ mm.
10.12	$F = 80.4$ kip.
10.14	$F = 3.02$ kN.
10.16	$m = 250$ kg.
10.18	$b = 3.10$ in, $F = 5.66$ kip.
10.20	$R_{AB} = 28.0$ mm, $R_{CD} = 0.798$ mm.
10.22	$F = 368$ N.
10.24	$F = 3.18$ kN.
10.26	$P = 1.25$ MN.
10.28	$P = 31.7$ kip.
10.30	$P = 588$ kN.
10.32	$P = 7.20$ MN. It bends in the x-y plane
10.34	$P = 1.66$ MN. It bends in the x-y plane

(continued)

10.36	
10.38	$P = \pi^2 EI/L^2$.
10.40	$L_e = L$, $L/2$, $L/3$, and $L/4$; $K = 1$, 1/2, 1/3, and 1/4.
10.42	$L_e = 2L$, $P = \pi^2 EI/4L^2$.
10.44	$v_{max} = 0.0102$ m.
10.46	$v_{max} = 0.781$ in.
10.48	$v_{max} = 0.738$ mm.
10.50	$v_{max} = 6.68$ mm.

10.52	$P = 264$ kN.
10.56	$P = 6.70$ MN.
10.58	$R_i = 15.5$ mm.
10.60	$h/b = 2.86$.
10.62	$\sigma_{max} = 161$ MPa.
11.2	**(a)** $U = 0.00167$ J (joules, or N-m). **(b)** $W = 0.00167$ J.
11.4	**(a)** $U = 386$ in-lb. **(b)** $W = 386$ in-lb.
11.6	$\theta = 0.00321$ rad (0.184°) counterclockwise
11.8	$F = 98.6$ kN.
11.10	$v = \left(1 + 2\sqrt{2}\right)FL_0/(EA)$.
11.12	$v = 0.833$ in.
11.14	$v = FL^3/12EI$.
11.16	$u = 1.24$ MJ/m^3.
11.20	$v = 0.0977$ in.
11.22	$\theta_B = w_0L^3/6EI$.
11.24	$v_B = M_0L^2/2EI$.
11.26	$v = FL^3/12EI$.
11.28	$3M_0/2L$ upward.
11.30	$v = 0.257$ in.
11.32	$v = 11.1$ mm.
12.2	$W = 6$ in.
12.4	Spacing is satisfactory
12.6	$C = 1.35$.
12.8	$d_2 = 1.0$ in.
12.10	Naval brass, hard
12.12	$a = 0.0855$ in.
12.14	10.2 MW.

(continued)

12.16	$W = 500$ kN.
12.18	Case (a).
12.20	$M = 50.7$ kN-m.
12.22	$a = 0.137$ m, $C = 1.4$.
12.24	$M = 23.7$ kN-m.
12.26	It will fail
12.28	It will suffice
12.30	No
12.32	15% increase
12.34	$\text{FS}_\text{T} = 1.20$.
12.36	$R = \left[\frac{10}{\pi\sigma_\text{Y}}\sqrt{M^2 + T^2}\right]^{1/3}$.
12.38	$\text{FS}_\text{M} = 13.1$.
12.40	$\tau_{xy} = 120$ MPa or $\tau_{xy} = -120$ MPa.
12.42	3320 cycles
12.44	Damage is 0.036, 0.376, and 0.520. 9.561E3 cycles
12.46	15.2 years
12.48	33, 800 cycles.
12.50	5.34 years
12.52	$\sigma = 6.76$ ksi.
12.54	(a) $\sigma = 17.4$ ksi. (b) $\sigma = 35.0$ ksi. (c) $\sigma = 47$ ksi.
12.56	$h = 0.5$ m.
12.58	Yes, the plate will fail
12.60	Yes, it will
12.62	$a = 0.221$ in.
12.64	$c_0 = 28.6$ mm. It is satisfied.
12.66	936 kilocycles.
12.68	$W = 2040$ lb.

12.70	(a) Yes. (b) Yes. (c) 650 kilocycles.
C.2	$\bar{x} = a(n+1)/(n+2),\ \bar{y} = ca^n(n+1)/(4n+2)$.
C.4	$\bar{x} = 0,\ \bar{y} = 1.6$ ft.
C.6	$\bar{x} = 0.5,\ \bar{y} = -7.6$.
C.8	$\bar{x} = \bar{y} = 4R/(3\pi)$.
C.10	$\bar{x} = 70.9$ mm, $\bar{y} = 0$.
C.12	$\bar{x} = 12.0$ in, $\bar{y} = 5.49$ in.
C.14	$\bar{x} = 344$ mm, $\bar{y} = 456$ mm.
C.16	$I_x = \frac{1}{12}bh^3,\ I_y = \frac{1}{12}hb^3,\ I_{xy} = \frac{1}{24}b^2h^2$.
C.18	$I_x = I_y = \frac{1}{16}\pi R^4, I_{xy} = \frac{1}{8}R^4$.
C.20	$I_x = 2.65\text{E}8$ mm^4.
C.22	$I_{xy} = 92.3$ ft^4.
C.24	$I_x = 237$ in^4, $I_y = 115$ in^4, $I_{xy} = 119$ in^4.
C.26	$I_x = 88.8$ m^4, $I_y = 65$ m^4.
C.28	$\theta_p = 0, I_{x'} = 85.33$ m^4, $I_{y'} = 5.33$ m^4.
C.30	$\theta_p = 35.6^\circ, I_{x'} = 1.02\text{E-}5$ m^4, $I_{y'} = 1.12\text{E-}6$ m^4.
C.32	$\theta_p = 26.6^\circ, I_{x'} = 10$ ft^4, $I_{y'} = 2.5$ ft^4.