

APPENDIX F

ANSWERS TO SELECTED PROBLEMS

CHAPTER 1

1.1 $\sigma = 1019 \text{ psi (T)}$

1.3 $W_{\max} = 125.6 \text{ lb}$

1.6 $d_{\min} = 1.5 \text{ mm}$

1.8 $\sigma = 2.57 \text{ MPa (T)}$

1.12 (a) $\sigma_{\text{col}} = 232.8 \text{ MPa (C)}$; (b) $\sigma_b = 20 \text{ MPa (C)}$

1.15 (a) $\sigma_{\text{col}} = 156 \text{ MPa (C)}$; (b) $\sigma_b = 8.33 \text{ MPa (C)}$

1.19 $\sigma_b = 3 \text{ MPa (C)}$

1.25 $P_{\max} = 10.8 \text{ kips}$

1.28 $P = \tau\pi(d_o + d_i)t$

1.31 $W_{\max} = 125.6 \text{ lb}$

1.44 $\sigma_{AA} = 3.286 \text{ ksi (T)}$; $\tau_{AA} = 1.53 \text{ ksi}$

1.51 $\sigma = 11.9 \text{ psi (T)}$; $V = 19 \text{ lbs}$

1.52 (a) $\sigma_{HA} = 38 \text{ MPa (C)}$; $\sigma_{HB} = 16 \text{ MPa (T)}$; $\sigma_{HG} = 22 \text{ MPa (C)}$; $\sigma_{HC} = 16 \text{ MPa (C)}$

(b) $(\tau_H)_{\max} = 53.76 \text{ MPa}$

1.56 $\sigma_{BD} = 100 \text{ MPa (T)}$; $\tau_{\max} = 259 \text{ MPa}$

1.62 $P_{\max} = 70.6 \text{ kN}$

1.67 $P_{\max} = 5684 \text{ lb}$

1.69 $L = 10.4 \text{ in}$

1.71 (a) $d_{CG} = 30 \text{ mm}$; $d_{CD} = 27 \text{ mm}$; $d_{CB} = 23 \text{ mm}$

(b) $d_C = 22 \text{ mm}$; sequence: *CB, CG, CD*

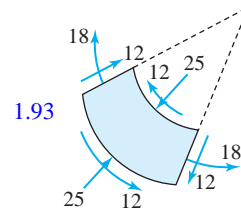
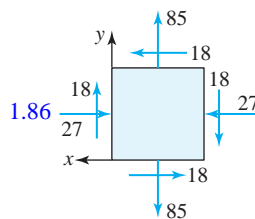
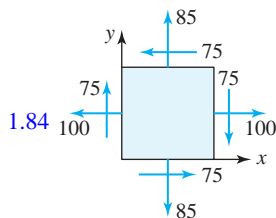
1.74 $\tau = 9947 \text{ Pa}$

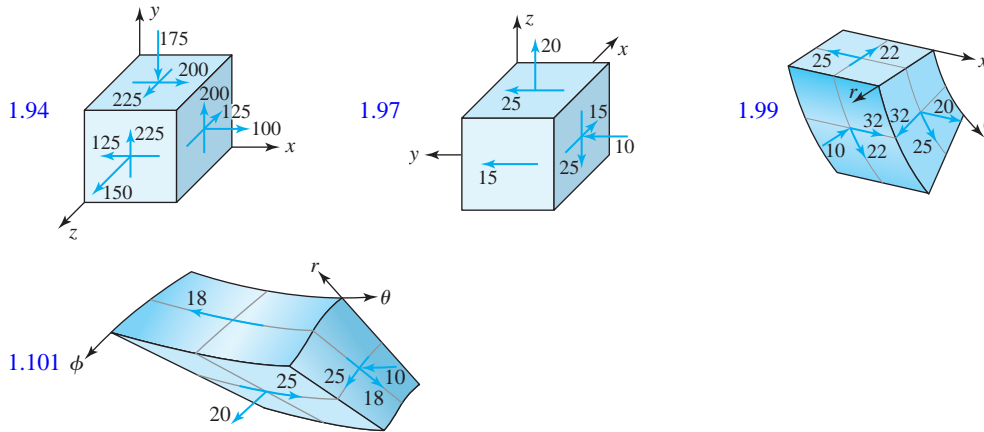
1.75 $P = 3 aL\tau$

1.77 $\tau = 3.18 \text{ MPa}$

1.79 $\tau = 226.3 \text{ MPa}$

1.82 (a) $\tau = 8.5 \text{ psi}$; (b) $T = 6.7 \text{ in-lb}$





CHAPTER 2

- 2.1 $\varepsilon = 0.9294 \text{ cm/cm}$
 2.4 $\varepsilon = 0.321 \text{ in/in}$
 2.7 $u_D - u_A = 2.5 \text{ mm}$
 2.8 $\varepsilon_A = 393.3 \mu\text{in/in}$; $\varepsilon_B = -150 \mu\text{in/in}$
 2.11 $\varepsilon_A = -0.0125 \text{ in/in}$
 2.13 $\varepsilon_A = -0.0108 \text{ in/in}$
 2.15 $\varepsilon_A = -0.0108 \text{ in/in}$; $\varepsilon_F = -0.003 \text{ in/in}$
 2.19 $\delta_B = 2 \text{ mm to the left}$
 2.21 $\delta_B = 2.5 \text{ mm to the left}$
 2.22 $\varepsilon_A = -416.7 \mu\text{mm/mm}$; $\varepsilon_F = 400 \mu\text{mm/mm}$
 2.29 $\gamma_A = -3000 \mu\text{rad}$
 2.32 $\gamma_A = 5400 \mu\text{rad}$
 2.34 $\gamma_A = 1296 \mu\text{rad}$
 2.38 $\gamma_A = -928 \mu\text{rad}$
 2.48 $\gamma_A = -1332 \mu\text{rad}$
 2.51 (a) $\varepsilon_{AP} = 1174.7 \mu\text{mm/mm}$; (b) $\varepsilon_{AP} = 1174.6 \mu\text{mm/mm}$; (c) $\varepsilon_{AP} = 1174.6 \mu\text{mm/mm}$
 2.54 $\delta_{AP} = 0.0647 \text{ mm extension}$; $\delta_{BP} = 0.2165 \text{ mm extension}$
 2.57 $\delta_{AP} = 0.0035 \text{ in contraction}$; $\delta_{BP} = 0.0188 \text{ in contraction}$
 2.61 $\varepsilon_{BC} = 4200 \mu\text{mm/mm}$; $\varepsilon_{CF} = -2973 \mu\text{mm/mm}$; $\varepsilon_{FE} = -2100 \mu\text{mm/mm}$
 2.64 $\varepsilon_{BC} = 500 \mu\text{mm/mm}$; $\varepsilon_{CG} = -833 \mu\text{mm/mm}$; $\varepsilon_{GB} = 0$; $\varepsilon_{CD} = 667.5 \mu\text{mm/mm}$
 2.68 $\varepsilon_{xx} = -128 \mu\text{mm/mm}$; $\varepsilon_{yy} = -666.7 \mu\text{mm/mm}$; $\gamma_{xy} = 3600 \mu\text{rad}$
 2.71 $\varepsilon_{xx} = 1750 \mu\text{mm/mm}$; $\varepsilon_{yy} = -1625 \mu\text{mm/mm}$; $\gamma_{xy} = -1125 \mu\text{rad}$
 2.74 $\varepsilon_{xx}(24) = 555 \mu\text{in/in}$
 2.77 $u(20) = 0.005 \text{ in}$
 2.80 $u(1250) = 1.516 \text{ mm}$
 2.85 $\varepsilon = 42.2 \mu\text{mm/mm}$
 2.87 $\varepsilon = 47\%$

CHAPTER 3

- 3.1 (a) $\sigma_{ult} = 510$ MPa; (b) $\sigma_{frac} = 480$ MPa (c) $E = 150(7.5)$ GPa; (d) $\sigma_{prop} = 300$ MPa (e) $\sigma_{yield} = 300$ MPa
 (f) $E_t = 2.5$ GPa; (g) $E_s = 6.5$ GPa
- 3.2 (a) $P = 23.56$ kN; (b) $P = 35.34$ kN
- 3.3 $\delta = 3.25$ mm
- 3.4 $\epsilon_{total} = 0.065$; $\epsilon_{elas} = 0.0028$; $\epsilon_{plas} = 0.0622$
- 3.5 $P = 36.9$ kN
- 3.12 (a) $E = 300$ GPa; (b) $\sigma_{prop} = 1022$ MPa;
 (c) $\sigma_{yield} = 1060$ MPa; (d) $E_t = 1.72$ GPa; (e) $E_s = 11.2$ GPa; (f) $\epsilon_{plas} = 0.1203$
- 3.16 $E = 25,000$ ksi; $\nu = 0.2$
- 3.18 $G = 4000$ ksi
- 3.25 $P = 70.7$ kN; $\Delta d = -0.008$ mm
- 3.27 0.0327%
- 3.31 $U = 125$ in.-lbs
- 3.36 (a) 300 kN-m/m³; (b) $21,960$ kN-m/m³; (c) $5,340$ kN-m/m³; (d) $57,623$ kN-m/m³.
- 3.38 (a) 1734 kN-m/m³; (b) 157 MN-m/m³; (c) 18 MN-m/m³; (d) 264 MN-m/m³
- 3.41 $F = 22.1$ kN
- 3.44 $F = 16.7$ kN
- 3.45 $F = 0.795$ lb; $\theta = 65.96^\circ$
- 3.50 $P_1 = 0$; $P_2 = 2$ kN
- 3.53 $h = 4\frac{3}{8}$ in; $d = 1\frac{1}{8}$ in
- 3.59 $d_{min} = 23$ mm
- 3.65 $N = 60$ kips; $M_z = 30$ in-kips
- 3.66 (a) $a = 1062.1$ MPa; $b = 4493.3$ MPa; $c = -12993.1$ MPa; (b) $E_T = 1.621$ GPa
- 3.68 $P = 70.1$ lbs
- 3.74 (a) $\sigma_{zz} = 0$; $\epsilon_{xx} = -3661 \mu$; $\epsilon_{yy} = 2589 \mu$; $\gamma_{xy} = 5357 \mu\text{rad}$; $\epsilon_{zz} = 357 \mu$;
 (b) $\epsilon_{zz} = 0$; $\sigma_{zz} = 25$ MPa (C); $\epsilon_{xx} = -3571 \mu$; $\epsilon_{yy} = 2679 \mu$; $\gamma_{xy} = 5357 \mu\text{rad}$
- 3.78 (a) $\sigma_{zz} = 0$; $\epsilon_{xx} = -0.06875$; $\epsilon_{yy} = 0.0875$; $\epsilon_{zz} = -0.00625$; $\gamma_{xy} = 0.125$
 (b) $\epsilon_{zz} = 0$; $\sigma_{zz} = 12.50$ psi(T); $\epsilon_{xx} = -0.0703$; $\epsilon_{yy} = 0.08594$; $\gamma_{xy} = 0.125$
- 3.81 $\sigma_{zz} = 0$; $\sigma_{yy} = 40.9$ ksi (C); $\sigma_{xx} = 36.26$ ksi (C); $\epsilon_{zz} = 771 \mu\text{in/in}$; $\tau_{xy} = -5.77$ ksi
- 3.83 $\sigma_{zz} = 0$; $\sigma_{yy} = 60$ MPa (T); $\sigma_{xx} = 60$ MPa (C); $\epsilon_{zz} = 0$; $\tau_{xy} = 18$ MPa
- 3.86 $\sigma_{xx} = 16$ ksi (C); $\sigma_{yy} = 4$ ksi (C)
- 3.92 $a = 50.06$ mm; $b = 50.1725$ mm
- 3.111 $\epsilon_{xx} = -936 \mu$; $\epsilon_{yy} = -2180 \mu$; $\gamma_{xy} = -5333 \mu$
- 3.115 $\sigma_{xx} = 19.07$ ksi (C); $\sigma_{yy} = 0.99$ ksi (C); $\tau_{xy} = 0.6$ ksi
- 3.119 $K = 2.4$
- 3.121 $\sigma_{max} = 45.3$ ksi
- 3.127 $\theta = 0.34^\circ$
- 3.130 $\sigma_{xx} = 47.4$ ksi (C); $\sigma_{yy} = 52.02$ ksi (C); $\epsilon_{zz} = 1254 \mu$; $\tau_{xy} = -5.77$ ksi
- 3.137 (a) $T = 33.33$ hours; (b) $T = 133.33$ hours; (c) $T = \infty$
- 3.139 $n = 400,000$ cycles
- 3.142 (a) $E_1 = 15,000$ ksi; (b) $E_2 = 64.15$ ksi; (c) $n = 0.1694$; $E = 56.2$ ksi

CHAPTER 4

- 4.2 $F_1 = 108.5$ kN; $F_2 = 45.2$ kN; $F_3 = 94.3$ kN
- 4.4 $F = 11.25$ kips
- 4.9 $u_D - u_A = -0.175$ in
- 4.13 (a) $u_D - u_A = -0.0234$ in; (b) $\sigma_{\max} = 3.75$ ksi (C)
- 4.18 $u_B - u_A = 0.126$ mm
- 4.20 $u = 0.4621 P/EK$
- 4.21 (a) $u_C - u_A = 0.034$ in; (b) $\sigma_{\max} = 33.95$ ksi (T)
- 4.24 $u_B = -\gamma L^2/2E$
- 4.27 $\delta = 0.045$ in
- 4.31 $F_{\max} = 4886$ lb
- 4.33 $d_p = 0.5$ in; $a_b = 1\frac{1}{8}$ in; $b_s = 1\frac{5}{16}$ in
- 4.41 (a) $\Delta u = 0.60$ mm; (b) $\sigma_{\max} = 62.2$ MPa (T)
- 4.44 $a = 224.40$; $b = -23.60$; $c = -0.40$; $u_A = 0.017$ in to the left
- 4.46 $F = 46.9$ kips
- 4.50 $\delta_p = 0.23$ mm
- 4.51 $\sigma_A = 8.0$ ksi (C); $\delta_B = 0.0021$ in
- 4.61 $\delta_p = 0.24$ mm; $\sigma_A = 118$ MPa (C)
- 4.65 (a) $\delta_p = 0.0265$ in; (b) $\Delta d_s = 0.00074$ in; $\Delta d_{al} = -0.00066$ in
- 4.67 $\sigma_A = 22.5$ ksi (C); $\sigma_B = 17.2$ ksi (T)
- 4.70 $F_{\max} = 555$ kN
- 4.74 $F_{\max} = 17.2$ kN
- 4.77 $w_{\max} = 9.4$ MPa
- 4.83 $P_{\max} = 106.7$ kips
- 4.85 $A_{BC} = 1.1$ in²; $d = 1.3$ in
- 4.87 $F_{\max} = 148.6$ kN
- 4.89 $F_{\max} = 181.9$ kN
- 4.90 $\sigma_A = 5.2$ ksi (T); $\sigma_B = 3.5$ ksi (T)
- 4.94 $\sigma_{xx} = 0$; $u(L/2) = \alpha T_L L/24$
- 4.95 $\sigma_{xx} = E\alpha T_L/3$ (C); $u(L/2) = -\alpha T_L L/8$
- 4.99 $\sigma_A = 25.70$ ksi (T)
- 4.100 $\sigma_{\theta\theta} = 10$ MPa (T); $\tau_r = 40$ MPa
- 4.104 $t_{\min} = 0.05$ in; $d_{noz} = 0.206$ in
- 4.106 $p_{\max} = 500$ psi; $d_{riv} = 0.85$ in

CHAPTER 5

- 5.1 $\gamma_D = 2400$ μ rad
- 5.2 $T = 64.8$ in-kips
- 5.7 $\phi_1 = 0.0400$ rad; $\phi_2 = 0.0243$ rad; $\phi_3 = 0.0957$ rad
- 5.11 $T = -495.2$ in-kips

- 5.13 $T = 10.9 \text{ kN-m}$
- 5.23 (a) $(\tau_{xy})_A > 0$; (b) $(\tau_{xy})_B < 0$
- 5.26 (a) $(\tau_{xy})_A > 0$; (b) $(\tau_{xy})_B < 0$
- 5.29 $\phi_D - \phi_A = 0.00711 \text{ rads CW}$
- 5.32 $\phi_D = 0.0163 \text{ rads CW}$; $\gamma_{max} = -1094\mu$; $(\tau_{x\theta})_E = -4.4 \text{ ksi}$
- 5.35 $\phi_A = 1676 \mu\text{rads CW}$; $(\tau_{x\theta})_E = 15.1 \text{ MPa}$
- 5.38 (a) $\phi_B = 0.1819(T_{\text{ext}}L/Gr^4) \text{ CCW}$; (b) $\tau_{\text{max}} = 0.275T_{\text{ext}}/r^3$
- 5.40 $\phi_A = (qL^2/GJ) \text{ CW}$
- 5.41 $T = 69.2 \text{ in-kips}$
- 5.43 $(r_i)_{\text{max}} = 24 \text{ mm}$
- 5.47 $d_{\text{min}} = 21 \text{ mm}$; $\tau_{AB} = 52.5 \text{ MPa}$
- 5.57 $R_o = 2\frac{3}{8} \text{ in}$
- 5.59 $\Delta\phi = 0.085 \text{ rad}$; $\tau_{\text{max}} = 172 \text{ MPa}$
- 5.60 $\Delta\phi = 0.088 \text{ rad}$
- 5.63 $\phi_B = 0.0516 \text{ rads ccw}$; $\tau_{\text{max}} = 25.8 \text{ ksi}$
- 5.66 $\phi_C = 0.006 \text{ rads CCW}$; $T = 200.5 \text{ in-kips}$
- 5.67 $\phi_B = 0.0438 \text{ rads CW}$
- 5.71 $\phi_B = 5.659\frac{TL}{Gd^4} \text{ CCW}$; $\tau_{\text{max}} = 2.83\frac{T}{d^3}$
- 5.74 $T_{\text{max}} = 32 \text{ kN-m}$; $\phi_B = 0.048 \text{ rads CCW}$; $\tau_{\text{max}} = 130.4 \text{ MPa}$
- 5.75 $d_{\text{min}} = 89 \text{ mm}$; $\phi_B = 0.0487 \text{ rads CCW}$; $\tau_{\text{max}} = 116 \text{ MPa}$
- 5.76 $d_{\text{min}} = 108 \text{ mm}$; $\phi_B = 0.025 \text{ rads CCW}$; $\tau_{\text{max}} = 58.62 \text{ MPa}$
- 5.95 $|\tau_{\text{max}}| = 10.8 \text{ MPa}$
- 5.101 $|\tau_{\text{max}}| = 21.65 \text{ MPa}$

CHAPTER 6

- 6.1 $\psi = 2.41^\circ$
- 6.3 $\varepsilon_1 = 182 \mu\text{m/m}$; $\varepsilon_3 = -109.1 \mu\text{m/m}$; $\varepsilon_4 = -654 \mu\text{m/m}$; $\varepsilon_6 = 393 \mu\text{m/m}$
- 6.6 $P = 1454\text{N}$; $M_z = 123.6 \text{ N-m}$
- 6.7 $P_1 = 14.58 \text{ kN}$; $M_1 = 130.3 \text{ N-m}$; $P_2 = 9.88 \text{ kN}$; $M_2 = 64.0 \text{ N-m}$
- 6.12 $M_z = 9.13 \text{ in-kips}$
- 6.14 $M_z = -2134 \text{ kN-m}$
- 6.25 $\sigma_T = 3.73\text{ksi}(T)$; $\sigma_C = 6.93\text{ksi}(C)$
- 6.29 $\sigma_A = 1224 \text{ psi}(C)$; $\sigma_B = 735 \text{ psi}(C)$; $\sigma_D = 1714 \text{ ksi}(T)$
- 6.35 σ_A is (C); σ_B is (T)
- 6.38 σ_A is (T); σ_B is (C)
- 6.42 (a) $\sigma_{3.0} = 2.96 \text{ ksi}(C)$; (b) $\sigma_{\text{max}} = 6.93 \text{ ksi}(C)$ or (T)
- 6.45 $\sigma_A = 4.17 \text{ ksi}(C)$; $\sigma_{\text{max}} = 12.5 \text{ ksi}(C)$ or (T)
- 6.49 $\sigma_A = 6.68 \text{ ksi}(C)$; $\sigma_{\text{max}} = 28.9 \text{ ksi}(T)$
- 6.51 $\varepsilon_A = -1500 \mu$
- 6.53 $\varepsilon_A = -327 \mu$

- 6.60 (a) $V_y = 3(72 - x)$ kips; (b) $M_z = 1.5(72 - x)^2$ in-kips
- 6.62 (a) $V_y = [108 - \frac{1}{48}x^2]$ kips; (b) $M_z = [5184 - 108x + \frac{1}{144}x^3]$ in-kips
- 6.64 $V_y = -wL$ kips $0 \leq x < L$; $M_z = (wLx - wL^2)$ in-kips $0 \leq x < L$;
 $V_y = [w(x - L) - wL]$ kips $L < x \leq 2L$; $M_z = [wLx - \frac{w}{2}(x - L)^2 - wL^2]$ in-kips $L < x \leq 2L$
- 6.68 $V_y = (76 - 12x)$ kN $5 \text{ m} < x < 9 \text{ m}$; $M_z = (6x^2 - 76x + 154)$ kN-m $5 \text{ m} < x < 9 \text{ m}$;
 $V_y = -20$ kN $9 \text{ m} < x < 12 \text{ m}$; $M_z = (20x - 240)$ kN-m $9 \text{ m} < x < 12 \text{ m}$
- 6.69 $V_y = -6x$ kN $0 \leq x < 3 \text{ m}$; $M_z = 3x^2$ kN-m $0 \leq x < 3 \text{ m}$;
 $V_y = -8$ kN $3 \text{ m} < x < 5 \text{ m}$; $M_z = (8x - 7)$ kN-m $3 \text{ m} < x < 5 \text{ m}$
- 6.74 $(V_y)_{\max} = \pm 7.5$ kN; $(M_z)_{\max} = 5.625$ kN-m
- 6.79 $(V_y)_{\max} = 36$ kN; $(M_z)_{\max} = -86.67$ kN-m
- 6.83 $(V_y)_{\max} = 9$ kN; $(M_z)_{\max} = -23.625$ kN-m
- 6.86 $(V_y)_{\max} = \pm 6$ kips; $(M_z)_{\max} = -16$ in-kips
- 6.92 $w_{\max} = 154.3$ lb/in
- 6.99 $a_i = 11\frac{7}{8}$ in
- 6.100 $r = 3.75$ mm
- 6.102 $P = 165.7$ N
- 6.107 Point A: negative τ_{xz} ; Point B: positive τ_{xy} ; Point C: negative τ_{xz} ; Point D: positive τ_{xz}
- 6.112 Point A: positive τ_{xy} ; Point B: negative τ_{xz} ; Point C: zero; Point D: positive τ_{xy}
- 6.117 $|\sigma_{\max}| = 348.4$ MPa; $|\tau_{\max}| = 6.84$ MPa; $(\sigma_{xx})_A = 48$ MPa (C); $(\tau_{xy})_A = -3.2$ MPa
- 6.120 $V_{AB} = 614.4$ lbs; $V_{BC} = 921.6$ lbs
- 6.124 $M_{\text{ext}} = 8333.33$ in-lbs
- 6.125 $P_{\max} = 202$ N; $\Delta s = 16$ cm
- 6.137 $R_O = 2\frac{3}{16}$ in
- 6.138 $|\sigma_{\max}| = 9185$ psi; $|\tau_{\max}| = 295$ psi

CHAPTER 7

- 7.2 $v(x) = -[wx/(24EI)](x^3 - 2Lx^2 + L^3)$; $v(L/2) = -[5wL^4/(384EI)]$
- 7.4 $v(x) = -[wx^2/(24EI)](x^2 - 4Lx + 6L^2)$; $v(L) = -[wL^4/(8EI)]$
- 7.9 $v_A = PL^3/(3EI)$
- 7.17 $v(x) = \begin{cases} [wLx/(9EI)](x^2 - 5L^2) & 0 \leq x \leq L \\ [wLx/(9EI)](x^2 - 5L^2) - [wL/(6EI)](x - L)^3 & L \leq x \leq 2L \end{cases}$; $v(L) = -(4wL^4/9EI)$
- 7.19 $v(x) = \begin{cases} (wLx/48EI)(2x^2 - 7L^2) & 0 \leq x \leq L \\ (w/EI)(2Lx^3 - 7L^3x)/48 - (w/24EI)(x - L)^4 & L \leq x \leq 2L \end{cases}$; $v(L) = -[5wL^4/(48EI)]$
- 7.25 $h(x) = \sqrt{6Px/(b\sigma)}$; $v_{\max} = -\sqrt{8b\sigma^3L^3/(27PE^2)}$
- 7.28 $\sigma_{\max} = 128PL/(27\pi d_0^3)$; $v_{\max} = -8PL^3/(3E\pi d_0^4)$
- 7.32 $R_A = 16.2$ kips up; $M_A = 10.8$ in-kips CCW
- 7.34 $R_A = 5P/2$; $v(x) = \begin{cases} (P/12EI)[2(x - 2L)^3 - 5(x - L)^3 - 9L^2x + 11L^3] & 0 \leq x \leq L \\ (P/12EI)[2(x - 2L)^3 - 9L^2x + 11L^3] & L \leq x \leq 2L \end{cases}$

$$7.36 \frac{dv}{dx}(L) = \frac{wL^3}{80EI}; R_A = \frac{61wL}{120} \text{ up}; M_A = 11wL^2/120 \text{ CW}$$

$$7.57 v_A = -41wL^4/24EI$$

$$7.61 v_A = -PL^3/96EI$$

$$7.64 v_A = -wL^4/136EI; R_C = 11wL/17; M_C = 5wL^2/34$$

$$7.67 v(x) = (w/18EI)[2Lx^3 - 3L(x-L)^3 - 10L^3x]; v(L) = -4wL^4/9EI$$

$$7.71 v(x) = (w/24EI)[x^4 - (x-L)^4 - 4L(x-2L)^3 - 12L^2(x-2L)^2 - 40L^3x + 71L^4]; v(2L) = (wL^4)/(4EI)$$

$$7.72 v(x) = (P/12EI)[3Lx^2 - 3x^3 + 5(x-L)^3]; R_A = 5P/2$$

$$7.76 v'(x_A) = -(wL^3/6EI); v(x_A) = -(wL^4/8EI)$$

CHAPTER 8

8.1 σ_{nn} is (C); τ_{nt} is positive

8.6 σ_{nn} is (C); τ_{nt} can't say

8.12 $\sigma_{nn} = 8.66$ ksi (C) $\tau_{nt} = 5.0$ ksi

8.15 Compression

8.19 $\sigma_{nn} = 50$ MPa (C); $\tau_{nt} = 40$ MPa

8.24 $\sigma_{nn} = 45.36$ ksi (C); $\tau_{nt} = 1.84$ ksi

8.26 $P_{\max} = 84.9$ lb

8.33 (a) $\sigma_{nn} = \sigma$ (T); $\tau_{nt} = 0$; (b) $\sigma_{nn} = 0$; $\tau_{nt} = -\sigma$

8.42 $\sigma_{nn} = 7$ MPa (T); $\tau_{nt} = -59.7$ MPa; $\sigma_1 = 75.2$ MPa (T); $\sigma_2 = 45.2$ MPa (C); $\sigma_3 = 0$; $\theta_1 = 69.2^\circ$;
 $\tau_{\max} = 60.2$ MPa

8.44 $\sigma_{nn} = 45.4$ ksi (C); $\tau_{nt} = 1.84$ ksi; $\sigma_1 = 15.4$ ksi (T); $\sigma_2 = 45.4$ ksi (C); $\sigma_3 = 0$; $\theta_1 = 40.3^\circ$;
 $\tau_{\max} = 30.4$ ksi

8.47 $\sigma_{nn} = 0.63$ ksi (C); $\tau_{nt} = -7.06$ ksi; $\sigma_1 = 0.62$ ksi (T); $\sigma_2 = 40.62$ ksi (C); $\sigma_3 = 12$ ksi (C) $\theta_1 = 128^\circ$;
 $\tau_{\max} = 20.62$ ksi

8.50 $\sigma_1 = 67.9$ MPa (T); $\sigma_2 = 207.9$ MPa (C); $\sigma_3 = 0$; $\theta_1 = 78^\circ$; $\tau_{\max} = 137.9$ MPa

8.54 $\sigma_{xx} = 7.54$ ksi (C); $\sigma_{yy} = 9.46$ ksi (C); $\tau_{xy} = 1.15$ ksi

8.60 $\sigma_{nn} = 16.5$ ksi (C); $\tau_{nt} = -9.55$ ksi

8.71 $P_{\max} = 30.6$ kN

CHAPTER 9

9.3 $\varepsilon_{nn} = -234.7 \mu$; $\phi = 196.96 \mu\text{rad CW}$

9.6 $\varepsilon_{nn} = 150 \mu$; $\varepsilon_{tt} = 450 \mu$; $\gamma_{nt} = -519.6 \mu$

9.8 $\varepsilon_{nn} = -70.2 \mu$; $\varepsilon_{tt} = -529.8 \mu$; $\gamma_{nt} = 385.67 \mu$

9.13 $\varepsilon_{nn} = -295.4 \mu$; $\varepsilon_{tt} = 295.4 \mu$; $\gamma_{nt} = -104.2 \mu$

9.16 Sectors 8 and 2 or Sectors 4 and 6

9.31 $\varepsilon_1 = 659 \mu$; $\varepsilon_2 = -459 \mu$; $\varepsilon_3 = 0$; $\gamma_{\max} = 1118 \mu$; $\theta_1 = 103.3^\circ$;

$\varepsilon_{nn} = 643.7 \mu$; $\varepsilon_{tt} = -443.7 \mu$; $\gamma_{nt} = -259.8 \mu$

9.37 $\varepsilon_1 = 1246.5 \mu$; $\varepsilon_2 = -196.5 \mu$; $\varepsilon_3 = 0$; $\gamma_{\max} = 1443 \mu$;

$$\varepsilon_{xx} = 1027 \mu; \quad \varepsilon_{yy} = 23 \mu; \quad \gamma_{xy} = -1037 \mu$$

$$9.42 \varepsilon_{xx} = -466 \mu; \quad \varepsilon_{yy} = 1266 \mu; \quad \gamma_{xy} = -1000 \mu$$

$$9.44 \varepsilon_1 = 767.9 \mu; \quad \varepsilon_2 = -125 \mu; \quad \varepsilon_3 = -214.3 \mu; \quad \gamma_{\max} = 982.2 \mu; \quad \theta_1 = -26.57^\circ$$

$$9.46 \varepsilon_1 = 681.4 \mu; \quad \varepsilon_2 = -604.3 \mu; \quad \varepsilon_3 = 0; \quad \gamma_{\max} = 642.9 \mu; \quad \theta_1 = 26.57^\circ$$

$$9.49 (\theta_1)_{\text{strain}} = 103.3^\circ; \quad (\theta_1)_{\text{stress}} = 98.8^\circ$$

$$9.54 \varepsilon_a = 33.49 \mu; \quad \varepsilon_b = 400 \mu; \quad \varepsilon_c = 166.5 \mu$$

$$9.58 \varepsilon_a = 687.5 \mu; \quad \varepsilon_b = -406.3 \mu; \quad \varepsilon_c = -656.9 \mu$$

$$9.62 \varepsilon_1 = 685.9 \mu; \quad \varepsilon_2 = -185.9 \mu; \quad \varepsilon_3 = -166.7; \quad \gamma_{\max} = 871.8 \mu; \quad \theta_1 = 48.3^\circ$$

$$9.64 \varepsilon = 392.9 \mu$$

$$9.68 \varepsilon = 716.7 \mu$$

$$9.74 \varepsilon = -112.5 \mu$$

CHAPTER 10

$$10.1 \sigma_{nm} = 4.6 \text{ ksi (C)}; \quad \tau_{nt} = -16.4 \text{ ksi}$$

$$10.4 P = 60.76 \text{ kN}$$

$$10.6 \varepsilon_a = 1696 \mu; \quad \varepsilon_b = -1176 \mu$$

$$10.12 \varepsilon_a = 1333 \mu; \quad \varepsilon_b = -666.66 \mu$$

$$10.24 (\sigma_{xx})_A = 0; \quad (\sigma_{xx})_B = -\sigma_{\text{bend-y}} = 85.39 \text{ MPa (C)}; \quad (\tau_{xz})_A = \tau_{\text{tor}} + \tau_{\text{bend-y}} = 42.89 \text{ MPa};$$

$$(\tau_{xy})_B = -\tau_{\text{tor}} = -25.62 \text{ MPa}$$

$$10.27 (\sigma_{xx})_A = 0; \quad (\sigma_{xx})_B = -\sigma_{\text{bend-y}} = 222 \text{ MPa (C)}; \quad (\tau_{xz})_A = \tau_{\text{bend-y}} = 17.27 \text{ MPa}; \quad (\tau_{xy})_B = 0$$

$$10.30 (\sigma_{\max})_A = 102.7 \text{ MPa (T) or (C)}; \quad (\sigma_{\max})_B = 137.33 \text{ MPa (C)}; \quad (\tau_{\max})_A = 51.35 \text{ MPa};$$

$$(\tau_{\max})_B = 91.79 \text{ MPa};$$

$$10.35 (\sigma_{xx})_A = 23.1 \text{ ksi (C)}; \quad (\tau_{xy})_A = -7.2 \text{ ksi}$$

$$10.36 \sigma_{nm} = 8219 \text{ psi (C)}; \quad \tau_{nt} = 13180 \text{ psi}$$

$$10.44 P_{\max} = 4.3 \text{ kN}$$

$$10.48 w = 791.2 \text{ N/m}$$

$$10.53 \sigma_{BD} = \sigma_{CE} = 5.13 \text{ psi (C)}; \quad \sigma_{BC} = 10 \text{ psi (T)}; \quad \sigma_{AB} = 167.4 \text{ psi (C)}$$

$$10.55 W_{\max} = 67 \text{ lb}$$

$$10.62 R_o = 2.405 \text{ in}$$

$$10.65 \text{ (a) } P_{\max} = 5 \text{ kN}; \quad \text{(b) } P_{\max} = 5.75 \text{ kN}$$

$$10.66 P_{\max} = 9.5 \text{ kips}$$

$$10.69 K = 1.22$$

CHAPTER 11

$$11.2 P_{cr} = 5/4 \text{ kL}$$

$$11.6 P_{cr} = 153.3 \text{ lb}$$

$$11.15 L/r = 72.7; \quad P_{cr} = 215.4 \text{ kip}; \quad \sigma_{cr} = 3.36 \text{ ksi (C)}$$

$$11.21 K = 1.106$$

$$11.25 K = 3.633$$

$$11.40 \quad L_{\max} = 42 \text{ in}$$

$$11.43 \quad w_{\max} = 12 \text{ kN/m}; \quad K_{BD} = 2.3$$

$$11.55 \quad \sigma_{\max} = 2.68 \text{ ksi (C)}; \quad v_{\max} = 0.0458 \text{ in}$$

$$11.59 \quad L_{\max} = 2.09 \text{ m}$$

$$11.63 \quad P_{\max} = 39.45 \text{ kip}$$

$$11.64 \quad P_{cr} = 17.0 \text{ kip}$$

FORMULA SHEET

$$\sigma_{av} = N/A \quad \tau_{av} = V/A \quad \sigma_{ij} = \lim_{\Delta A_i \rightarrow 0} \left(\frac{\Delta F_i}{\Delta A_i} \right)$$

$$\varepsilon = \frac{L_f - L_o}{L_o} \quad \varepsilon = \frac{\delta}{L_o} \quad \varepsilon = \frac{u_B - u_A}{x_B - x_A} \quad \gamma = \pi/2 - \alpha \quad \varepsilon_{xx} = \frac{du(x)}{dx}$$

$$\varepsilon_{xx} = [\sigma_{xx} - \nu(\sigma_{yy} + \sigma_{zz})]/E \quad \gamma_{xy} = \tau_{xy}/G \quad G = \frac{E}{2(1 + \nu)}$$

$$\sigma_{xx} = [\varepsilon_{xx} + \nu\varepsilon_{yy}] \frac{E}{(1 - \nu^2)} \quad \varepsilon_{zz} = -\left(\frac{\nu}{1 - \nu}\right)(\varepsilon_{xx} + \varepsilon_{yy})$$

$$\frac{du}{dx} = \frac{N}{EA} \quad u_2 - u_1 = \frac{N(x_2 - x_1)}{EA} \quad \delta = \frac{NL}{EA} \quad \sigma_{xx} = \frac{N}{A}$$

$$\frac{d\phi}{dx} = \frac{T}{GJ} \quad \phi_2 - \phi_1 = \frac{T(x_2 - x_1)}{GJ} \quad \tau_{x\theta} = \frac{T\rho}{J}$$

$$M_z = EI_{zz} \frac{d^2v}{dx^2} \quad \sigma_{xx} = -\frac{M_z y}{I_{zz}} \quad \tau_{xs} = -\frac{V_y Q_z}{I_{zz} t}$$

$$\sigma_{xx} = -\frac{M_y z}{I_{yy}} \quad \tau_{xs} = -\frac{V_z Q_y}{I_{yy} t}$$

$$V_y = -V \quad \frac{dV}{dx} = p \quad \frac{dM_z}{dx} = V \quad V_2 = V_1 + \int_{x_1}^{x_2} p \, dx \quad M_2 = M_1 + \int_{x_1}^{x_2} V \, dx$$

$$\sigma_{nn} = \sigma_{xx} \cos^2 \theta + \sigma_{yy} \sin^2 \theta + 2\tau_{xy} \sin \theta \cos \theta \quad \tau_{nt} = -\sigma_{xx} \cos \theta \sin \theta + \sigma_{yy} \sin \theta \cos \theta + \tau_{xy}(\cos^2 \theta - \sin^2 \theta)$$

$$\tan 2\theta_p = \frac{2\tau_{xy}}{(\sigma_{xx} - \sigma_{yy})} \quad \sigma_{1,2} = \frac{(\sigma_{xx} + \sigma_{yy})}{2} \pm \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2} \quad \tau_{\max} = \left| \max\left(\frac{\sigma_1 - \sigma_2}{2}, \frac{\sigma_2 - \sigma_3}{2}, \frac{\sigma_3 - \sigma_1}{2}\right) \right|$$

$$\varepsilon_{nn} = \varepsilon_{xx} \cos^2 \theta + \varepsilon_{yy} \sin^2 \theta + \gamma_{xy} \sin \theta \cos \theta \quad \gamma_{nt} = -2\varepsilon_{xx} \sin \theta \cos \theta + 2\varepsilon_{yy} \sin \theta \cos \theta + \gamma_{xy}(\cos^2 \theta - \sin^2 \theta)$$

$$\tan 2\theta_p = \frac{\gamma_{xy}}{(\varepsilon_{xx} - \varepsilon_{yy})} \quad \varepsilon_{1,2} = \frac{(\varepsilon_{xx} + \varepsilon_{yy})}{2} \pm \sqrt{\left(\frac{\varepsilon_{xx} - \varepsilon_{yy}}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2} \quad \frac{\gamma_{\max}}{2} = \left| \max\left(\frac{\varepsilon_1 - \varepsilon_2}{2}, \frac{\varepsilon_2 - \varepsilon_3}{2}, \frac{\varepsilon_3 - \varepsilon_1}{2}\right) \right|$$

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

$$\eta_C = \frac{4r}{3\pi} \quad I = \frac{1}{12} ab^3 \quad I = \frac{1}{4} \pi r^4 \quad J = \frac{1}{2} \pi r^4$$