APPENDIX F

ANSWERS TO SELECTED PROBLEMS

CHAPTER 1

1.1 σ = 1019 psi (T)

1.3 $W_{\max}$ = 125.6 lb

1.6 $d_{\min}$ = 1.5 mm

1.8 $\sigma = 2.57MPa(T)$

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

1.15 (a) σ_{col} = 156 MPa (C); (b) σ_b = 8.33 MPa (C)

1.19 σ_b = 3 MPa (C)

1.25 P_{max} = 10.8 *kips*

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

1.31 $W_{\max}$ = 125.6 lb

1.44 σ_{AA} = 3.286 ksi (T); τ_{AA} = 1.53 ksi

1.51 σ = 11.9 psi (T); V = 19 lbs

1.52 (a) σ_{HA} = 38 MPa (C); σ_{HB} = 16 MPa (T); σ_{HG} = 22 MPa (C); σ_{HC} = 16 MPa (C)

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

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

1.62 $P_{\max}$ = 70.6 kN

1.67 $P_{\max}$ = 5684 lb

1.69 L = 10.4 in

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

(b) d_C = 22 mm; sequence: *CB*, *CG*, *CD*

1.74 τ = 9947 *Pa*

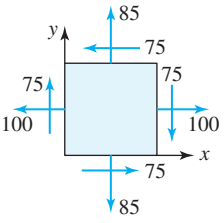
1.75 $P = 3\,aL\,\tau$

1.77 τ = 3.18 MPa

1.79 τ = 226.3 MPa

1.82 (a) τ = 8.5 psi; (b) T = 6.7 in-lb

1.84



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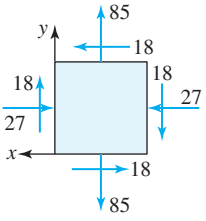

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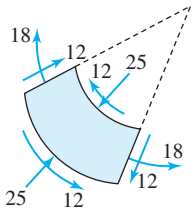

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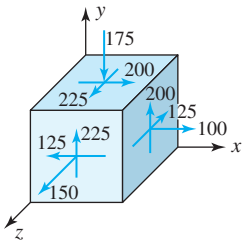

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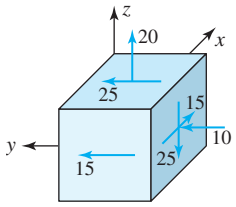

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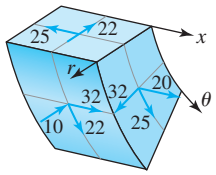

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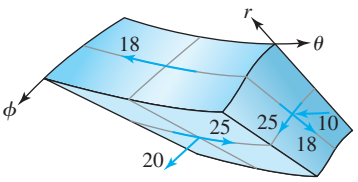

CHAPTER 2

2.1 $\varepsilon = 0.9294$ cm/cm

2.4 $\varepsilon = 0.321$ in/in

2.7 $u_D - u_A = 2.5$ mm

2.8 $\varepsilon_A = 393.3\ \mu$in/in; $\varepsilon_B = -150\ \mu$in/in

2.11 $\varepsilon_A = -0.0125$ in/in

2.13 $\varepsilon_A = -0.0108$ in/in

2.15 $\varepsilon_A = -0.0108$ in/in; $\varepsilon_F = -0.003$ in/in

2.19 $\delta_B = 2$ mm to the left

2.21 $\delta_B = 2.5$ mm to the left

2.22 $\varepsilon_A = -416.7\ \mu$mm/mm; $\varepsilon_F = 400\ \mu$mm/mm

2.29 $\gamma_A = -3000\ \mu$rad

2.32 $\gamma_A = 5400\ \mu$rad

2.34 $\gamma_A = 1296\ \mu$rad

2.38 $\gamma_A = -928\ \mu$rad

2.48 $\gamma_A = -1332\ \mu$rad

2.51 (a) $\varepsilon_{AP} = 1174.7\ \mu$mm/mm; (b) $\varepsilon_{AP} = 1174.6\ \mu$mm/mm; (c) $\varepsilon_{AP} = 1174.6\ \mu$mm/mm

2.54 $\delta_{AP} = 0.0647$ mm extension; $\delta_{BP} = 0.2165$ mm extension

2.57 $\delta_{AP} = 0.0035$ in contraction; $\delta_{BP} = 0.0188$ in contraction

2.61 $\varepsilon_{BC} = 4200\ \mu$mm/mm; $\varepsilon_{CF} = -2973\ \mu$mm/mm; $\varepsilon_{FE} = -2100\ \mu$mm/mm

2.64 $\varepsilon_{BC} = 500\ \mu$mm/mm; $\varepsilon_{CG} = -833\ \mu$mm/mm; $\varepsilon_{GB} = 0$; $\varepsilon_{CD} = 667.5\ \mu$mm/mm

2.68 $\varepsilon_{xx} = -128\ \mu$mm/mm; $\varepsilon_{yy} = -666.7\ \mu$mm/mm; $\gamma_{xy} = 3600\ \mu$rad

2.71 $\varepsilon_{xx} = 1750\ \mu$mm/mm; $\varepsilon_{yy} = -1625\ \mu$mm/mm; $\gamma_{xy} = -1125\ \mu$rad

2.74 $\varepsilon_{xx}(24) = 555\ \mu$in/in

2.77 $u(20) = 0.005$ in

2.80 $u(1250) = 1.516$ mm

2.85 $\varepsilon = 42.2\ \mu$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 $\varepsilon_{total} = 0.065$; $\varepsilon_{elas} = 0.0028$; $\varepsilon_{plas} = 0.0622$

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) $\varepsilon_{plas} = 0.1203$

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/m^3; (b) 21,960 kN-m/m^3; (c) 5,340 kN-m/m^3; (d) 57,623 kN-m/m^3.

3.38 (a) 1734 kN-m/m^3; (b) 157 MN-m/m^3; (c) 18 MN-m/m^3; (d) 264 MN-m/m^3

3.41 $F = 22.1$ kN

3.44 $F = 16.7$ kN

3.45 $F = 0.795$ lb; $\theta = 65.96°$

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 $\boldsymbol{N} = 60$ kips; $\boldsymbol{M}_z = 30$ 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) $\sigma_{zz} = 0$; $\varepsilon_{xx} = -3661\ \mu$; $\varepsilon_{yy} = 2589\ \mu$; $\gamma_{xy} = 5357\ \mu$rad; $\varepsilon_{zz} = 357\ \mu$;

(b) $\varepsilon_{zz} = 0$; $\sigma_{zz} = 25$ MPa (C); $\varepsilon_{xx} = -3571\ \mu$; $\varepsilon_{yy} = 2679\ \mu$; $\gamma_{xy} = 5357\ \mu$rad

3.78 (a) $\sigma_{zz} = 0$; $\varepsilon_{xx} = -0.06875$; $\varepsilon_{yy} = 0.0875$; $\varepsilon_{zz} = -0.00625$; $\gamma_{xy} = 0.125$

(b) $\varepsilon_{zz} = 0$; $\sigma_{zz} = 12.50psi(T)$; $\varepsilon_{xx} = -0.0703$; $\varepsilon_{yy} = 0.08594$; $\gamma_{xy} = 0.125$

3.81 $\sigma_{zz} = 0$; $\sigma_{yy} = 40.9$ ksi (C); $\sigma_{xx} = 36.26$ ksi (C); $\varepsilon_{zz} = 771\ \mu$in/in; $\tau_{xy} = -5.77$ ksi

3.83 $\sigma_{zz} = 0$; $\sigma_{yy} = 60$ MPa (T); $\sigma_{xx} = 60$ MPa (C); $\varepsilon_{zz} = 0$; $\tau_{xy} = 18$ 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 $\varepsilon_{xx} = -936\ \mu$; $\varepsilon_{yy} = -2180\ \mu$; $\gamma_{xy} = -5333\ \mu$

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 $\theta = 0.34°$

3.130 $\sigma_{xx} = 47.4$ ksi (C); $\sigma_{yy} = 52.02$ ksi (C); $\varepsilon_{zz} = 1254\ \mu$; $\tau_{xy} = -5.77$ 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; $\Delta d_{\text{al}} = -0.00066$ 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 $A_{BC} = 1.1$ in^2; $d = 1.3$ 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; $d_{\text{noz}} = 0.206$ in

4.106 $p_{\max} = 500$ psi; $d_{\text{riv}} = 0.85$ in

CHAPTER 5

5.1 $\gamma_D = 2400\ \mu$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 $\boldsymbol{T} = -495.2$ in-kips

5.13 $\boldsymbol{T}$ = 10.9 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 rads CW

5.32 ϕ_D = 0.0163 rads CW; $\gamma_{max} = -1094\mu$; $(\tau_{x\theta})_E$ = –4.4 ksi

5.35 ϕ_A = 1676 μrads CW; $(\tau_{x\theta})_E$ = 15.1 MPa

5.38 (a) $\phi_B = 0.1819(T_{\text{ext}}L/Gr^4)$ CCW; (b) $\tau_{\max} = 0.275T_{\text{ext}}/r^3$

5.40 $\phi_A = (qL^2/GJ)$ CW

5.41 T = 69.2 in-kips

5.43 $(r_i)_{\max}$ = 24 mm

5.47 $d_{\min}$ = 21 mm; τ_{AB} = 52.5 MPa

5.57 $R_o = 2\frac{3}{8}$ in

5.59 $\Delta\phi$ = 0.085 rad; $\tau_{\max}$ = 172 MPa

5.60 $\Delta\phi$ = 0.088 rad

5.63 ϕ_B = 0.0516 rads ccw; $\tau_{\max}$ = 25.8 ksi

5.66 ϕ_C = 0.006 rads CCW; T = 200.5 in-kips

5.67 ϕ_B = 0.0438 rads CW

5.71 $\phi_B = 5.659\dfrac{TL}{Gd^4}$ CCW; $\tau_{\max} = 2.83\ \dfrac{T}{d^3}$

5.74 $T_{\max}$ = 32 kN-m; ϕ_B = 0.048 rads CCW; $\tau_{\max}$ = 130.4 MPa

5.75 $d_{\min}$ = 89 mm; ϕ_B = 0.0487 rads CCW; $\tau_{\max}$ = 116 MPa

5.76 $d_{\min}$ = 108 mm; ϕ_B = 0.025 rads CCW; $\tau_{\max}$ = 58.62 MPa

5.95 $|\tau_{\max}|$ = 10.8 MPa

5.101 $|\tau_{\max}|$ = 21.65 MPa

CHAPTER 6

6.1 ψ = 2.41°

6.3 ε_1 = 182 μm/m; ε_3 = –109.1 μm/m; ε_4 = –654 μm/m; ε_6 = 393 μm/m

6.6 $P = 1454N$; M_z = 123.6 N-m

6.7 P_1 = 14.58 kN; M_1 = 130.3 N-m; P_2 = 9.88 kN; M_2 = 64.0 N-m

6.12 $\boldsymbol{M}_z$ = 9.13 in-kips

6.14 $\boldsymbol{M}_z$ = –2134 kN-m

6.25 $\sigma_T = 3.73ksi(T)$; $\sigma_C = 6.93ksi(C)$

6.29 σ_A = 1224 psi (C); σ_B = 735 psi (C); σ_D = 1714 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 ksi (C); (b) $\sigma_{\max}$ = 6.93 ksi (C) or (T)

6.45 σ_A = 4.17 ksi (C); $\sigma_{\max}$ = 12.5 ksi (C) or (T)

6.49 σ_A = 6.68 ksi (C); $\sigma_{\max}$ = 28.9 ksi (T)

6.51 ε_A = –1500 μ

6.53 ε_A = –327 μ

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 $\quad 0 \le x < L$; $\quad M_z = (wLx - wL^2)$ in-kips $\quad 0 \le x < L$;

$V_y = [w(x - L) - wL]$ kips $\quad L < x \le 2L$; $\quad M_z = [wLx - \frac{w}{2}(x - L)^2 - wL^2]$ in-kips $\quad L < x \le 2L$

6.68 $V_y = (76 - 12x)$ kN $\quad 5$ m $< x < 9$ m; $\quad M_z = (6x^2 - 76x + 154)$ kN-m $\quad 5$ m $< x < 9$ m;

$V_y = -20$ kN $\quad 9$ m $< x < 12$ m; $\quad M_z = (20x - 240)$ kN-m $\quad 9$ m $< x < 12$ m

6.69 $V_y = -6x$ kN $\quad 0 \le x < 3$ m; $\quad M_z = 3x^2$ kN-m $\quad 0 \le x < 3$ m;

$V_y = -8$ kN $\quad 3$ m $< x < 5$ m; $\quad M_z = (8x - 7)$ kN-m $\quad 3$ m $< x < 5$ m

6.74 $(V_y)_{\max} = \pm 7.5$ kN; $\quad (M_z)_{\max} = 5.625$ kN-m

6.79 $(V_y)_{\max} = 36$ kN; $\quad (M_z)_{\max} = -86.67$ kN-m

6.83 $(V_y)_{\max} = 9$ kN; $\quad (M_z)_{\max} = -23.625$ kN-m

6.86 $(V_y)_{\max} = \pm 6$ kips; $\quad (M_z)_{\max} = -16$ 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; $\quad |\tau_{\max}| = 6.84$ MPa; $\quad (\sigma_{xx})_A = 48$ MPa (C); $\quad (\tau_{xy})_A = -3.2$ MPa

6.120 $V_{AB} = 614.4$ lbs; $\quad V_{BC} = 921.6$ lbs

6.124 $M_{\text{ext}} = 8333.33$ in-lbs

6.125 $P_{\max} = 202$ N; $\quad \Delta s = 16$ cm

6.137 $R_O = 2\frac{3}{16}$ in

6.138 $|\sigma_{\max}| = 9185$ psi; $\quad |\tau_{\max}| = 295$ psi

CHAPTER 7

7.2 $v(x) = -[wx/(24EI)](x^3 - 2Lx^2 + L^3)$; $\quad v(L/2) = -[5wL^4/(384EI)]$

7.4 $v(x) = -[wx^2/(24EI)](x^2 - 4Lx + 6L^2)$; $\quad v(L) = -[wL^4/(8EI)]$

7.9 $v_A = PL^3/(3EI)$

7.17 $v(x) = \begin{cases} [wLx/(9EI)](x^2 - 5L^2) & 0 \le x \le L \\ [wLx/(9EI)](x^2 - 5L^2) - [wL/(6EI)](x - L)^3 & L \le x \le 2 \end{cases}$; $\quad v(L) = -(4wL^4/9EI)$

7.19 $v(x) = \begin{cases} (wLx/48EI)(2x^2 - 7L^2) & 0 \le x \le L \\ (w/EI)(2Lx^3 - 7L^3x)/48 - (w/24EI)(x - L)^4 & L \le x \le 2L \end{cases}$; $\quad v(L) = -[5wL^4/(48EI)]$

7.25 $h(x) = \sqrt{6Px/(b\sigma)}$; $\quad v_{\max} = -\sqrt{8b\sigma^3L^3/(27PE^2)}$

7.28 $\sigma_{\max} = 128PL/(27\pi d_0^3)$; $\quad v_{\max} = -8PL^3/(3E\pi d_0^4)$

7.32 $R_A = 16.2$ kips up; $\quad M_A = 10.8$ in-kips CCW

7.34 $R_A = 5P/2$; $\quad v(x) = \begin{cases} (P/12EI)[2(x - 2L)^3 - 5(x - L)^3 - 9L^2x + 11L^3] & 0 \le x \le L \\ (P/12EI)[2(x - 2L)^3 - 9L^2x + 11L^3] & L \le x \le 2L \end{cases}$

7.36 $\frac{dv}{dx}(L) = \frac{wL^3}{80EI}$; $R_A = \frac{61wL}{120}$ up; $M_A = 11wL^2/120$ 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 $v(x) = (w/18EI)[2Lx^3 - 3L\langle x-L\rangle^3 - 10L^3x]$; $v(L) = -4wL^4/9EI$

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

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

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); $\sigma_3 = 0$; $\theta_1 = 69.2°$; $\tau_{max} = 60.2$ 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); $\sigma_3 = 0$; $\theta_1 = 40.3°$; $\tau_{max} = 30.4$ 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) $\theta_1 = 128°$; $\tau_{max} = 20.62$ ksi

8.50 $\sigma_1 = 67.9$ MPa (T); $\sigma_2 = 207.9$ MPa(C); $\sigma_3 = 0$; $\theta_1 = 78°$; $\tau_{max} = 137.9$ 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 $\varepsilon_{nn} = -234.7\ \mu$; $\phi = 196.96\ \mu$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 $\varepsilon_1 = 659\ \mu$; $\varepsilon_2 = -459\ \mu$; $\varepsilon_3 = 0$; $\gamma_{max} = 1118\ \mu$; $\theta_1 = 103.3°$; $\varepsilon_{nn} = 643.7\ \mu$; $\varepsilon_{tt} = -443.7\ \mu$; $\gamma_{nt} = -259.8\ \mu$

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

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

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

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

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

9.49 $(\theta_1)_{strain} = 103.3^o$; $(\theta_1)_{stress} = 98.8°$

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

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

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

9.64 $\varepsilon = 392.9\ \mu$

9.68 $\varepsilon = 716.7\ \mu$

9.74 $\varepsilon = -112.5\ \mu$

CHAPTER 10

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

10.4 $P = 60.76$ kN

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

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

10.24 $(\sigma_{xx})_A = 0$; $(\sigma_{xx})_B = -\sigma_{\text{bend-}y} = 85.39MPa(C)$; $(\tau_{xz})_A = \tau_{\text{tor}} + \tau_{\text{bend-}y} = 42.89MPa$;
$(\tau_{xy})_B = -\tau_{\text{tor}} = -25.62MPa$

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

10.30 $(\sigma_{max})_A = 102.7MPa(T)\ or\ (C)$; $(\sigma_{max})_B = 137.33MPa(C)$; $(\tau_{max})_A = 51.35MPa$;
$(\tau_{max})_B = 91.79MPa$;

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

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

10.44 $P_{\max} = 4.3$ kN

10.48 $w = 791.2$ N/m

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

10.55 $W_{\max} = 67$ lb

10.62 $R_o = 2.405$ in

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

10.66 $P_{\max} = 9.5$ kips

10.69 $K = 1.22$

CHAPTER 11

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

11.6 $P_{cr} = 153.3$ lb

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

11.21 $K = 1.106$

11.25 $K = 3.633$

11.40 $L_{\max} = 42$ in

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

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

11.59 $L_{\max} = 2.09$ m

11.63 $P_{\max} = 39.45$ kip

11.64 $P_{cr} = 17.0$ kip

FORMULA SHEET

$$\sigma_{av} = N/A \qquad \tau_{av} = V/A \qquad \sigma_{ij} = \lim_{\Delta A_i \to 0}\left(\frac{\Delta F_j}{\Delta A_i}\right)$$

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

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

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

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

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

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

$$\sigma_{xx} = -\left(\frac{M_y z}{I_{yy}}\right) \qquad \tau_{xs} = -\left(\frac{V_z Q_y}{I_{yy} t}\right)$$

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

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

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

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

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

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

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