E 126 - Answers to Class Problems - Fall 2020

Concurrent Force Systems

1-1. F_R = 213 N; θ = 54.8° (ccw from positive x-axis)

1-2. θ = 76.1° (cw from positive x-axis)

1-3. F_R = 463 lb

1-4. θ = 21.3°; F_1 = 869 N

1-5. F_R = 161 lb; θ = 38.3° (cw from positive x-axis)

1-6. F = 2.03 kN; F_R = 7.87 kN

Moment of a Force about a Point

2-1. M_O = – 98.6 N-m

2-2. M_{O_F1} = + 4125 lb-ft; M_{O_F2} = + 2000 lb-ft; M_{O_F1} = + 40 lb-ft

2-3. F_3 = 1592.7 N

Moment of a Force about an Axis / Moment of a Couple

2-4. M_z = 62 lb-in

2-5. M_R = – 53.4 lb-ft

Equivalent Force and Couple Systems

2-6. F_R = 962 N; θ = 66.6° (ccw from negative x-axis); M_{RA} = 551 N-m (cw)

2-7. F_R = 991.0 N; θ = 63° (ccw from negative x-axis); M_{RA} = 800 N-m (ccw)

2-8. F_R = 420.5 N; θ = 33.7° (cw from positive x-axis); d = 5.07 m

Distributed Loads

2-9. a = 7.5 ft; b = 9 ft

2-10. F = 2700 N @ x = 5.56 m

Concurrent/Particle Equilibrium

3-1. F_{AB} = 4.91 kN; F_{AD} = 4.25 kN

3-2. F_1 = 339 N; F_2 = 400 N

3-3. y = 1.768 ft

3-4. T_A = 1507 N; T_B = 2970 N; T_C = 2832 N; T_D = 1416 N

3-5. T = 200 kN ; α = 6.44°

3-6. F_{BC} = 145 N; F_{BD} = 171 N

3-7. F_{BC} = 707.1 N (C); F_{AB} = 500 N (T); F_{AC} = 500 N (T)

2D Rigid Body Equilibrium

3-8. A_x = 100 N (→); A_y = 233 N (↑); N_B = 200 N (↙)

3-9. A_x = 150 lb (←); A_y = 300 lb (↑); N_B = 150 lb (→)

3-10. A_x = 0; A_y = 2 kN (↑); M_R = 11 kN-m (ccw)

3-11. R_A = 1.06 kN (↗); R_B = 1.42 kN (↑); R_C = 0.501 kN (→)

3-12. F_{AB} = 0.864 kN (↗); C_x= 2.66 kN (←); C_y = 6.56 kN (↓)

3-13. A_x = 33.4 lb (→); A_y = 61.3 lb (↑); T = 74.6 lb

3-14. A_x = 512.8 lb (→); A_y = 638.9 lb (↑); B = 598 lb (50° ccw from positive x-axis); N_C = 199.5 lb (↖)

Normal and Shear Stress

4-1. σ_{max} = 85.7 MPa

4-2. τ_{avg} = 31.8 ksi

4-3. P_{max} = 113.7 kN; P_{max} = 54.3 kN

4-4. τ_A = 34.0 MPa; τ_B = 17.7 MPa

4-5. $\sigma_{a\text{-}a}$ = 500 kPa, $\tau_{a\text{-}a}$ = 0; $\sigma_{b\text{-}b}$ = 375 kPa, $\tau_{b\text{-}b}$ = 217 kPa

4-6. d_B = 1.18 in; d_C = 1.11 in

Strain / Mechanical Properties of Materials

5-1. d_{min} = 20.6 mm; t_{min} = 4.55 mm

5-2. $\varepsilon_{AB} = -7.93 \times 10^{-3}$; γ_{xy} = 0.0121 rad

5-3. ΔL_z = 120 μm–; ΔL_x = –2.40 μm; ΔL_y = –1.20 μm

5-4. E = 70.0 GPa; Δd = 0.0415 mm

Axial Load and Deformation

6-1. $\delta_A = +0.0127$ in; $\delta_{B/C} = +0.00217$ in

6-2. $\delta_F = 0.225$ mm (↓)

6-3. $t_{min} = 8.73$ mm

6-4. $\delta_{BC} = 0.102$ mm

6-5. $F_A = 16.6$ kN; $F_B = 3.4$ kN

6-6. $\sigma_{Al} = 0.637$ ksi; $\sigma_{Br} = 0.955$ ksi

6-7. $\sigma_B = 12$ ksi; $\sigma_D = 24$ ksi; $\delta_B = 0.008$ in; $\delta_D = 0.016$ in

Trusses

7-1. $F_{AB} = 750$ N (C); $F_{AD} = 450$ N (T); $F_{BD} = 250$ N (T); $F_{BC} = 600$ N (C); $F_{CD} = 200$ N (C)

7-2. $F_{AB} = 5000$ lb (T); $F_{AE} = 1000$ lb (T); $F_{BE} = 1666.7$ lb (C); $F_{DE} = F_{CD} = 2666.7$ lb (C); $F_{BC} = 3333.3$ lb (T); $F_{BD} = 2000$ lb (T)

7-3. $F_{CD} = 50$ kN (T); $F_{HD} = 7.07$ kN (C); $F_{GD} = 5$ kN (T)

7-4. $F_{DE} = 11.9$ kN (C); $F_{DJ} = 2.66$ kN (T); Zero-force members: BL, BK, CK, JE, EI, IF, FH

7-5. $F_{HC} = 150$ kN (C); $F_{BC} = 40$ kN (C); $F_{JD} = 0$; $F_{KD} = 102.1$ kN (C); $F_{LF} = 40$ kN (T)

7-6. Zero-force members: CG, DF, CF

Frames and Machines

8-1. $C_x = 1230$ N (→); $C_y = 245$ N (↓)

8-2. $A_x = 70$ lb (→); $A_y = 8.75$ lb (↓); $F_{BE} = 61.3$ lb (↓); $C_x = 70$ lb (←); $C_y = 70$ lb (↑);

8-3. $B_x = 0$; $B_y = 1050$ lb (↓); $C_x = 0$; $C_y = 1000$ lb (↑); $F_E = 1500$ lb

8-4. $A_x = 577$ N (→); $A_y = 1000$ N (↑); $C_x = 577$ N (←); $C_y = 1000$ N (↑)

8-5. $F_{DB} = 2.60$ kN (C); $F_{FB} = 1.94$ kN (C)

8-6. $A_x = 300$ N (←); $A_y = 300$ N (↑); $C_x = 300$ N (→); $C_y = 300$ N (↑)

Geometric Properties of Areas

9-1. $x = 1.50$ in; $y = 2.00$ in

9-2. $x = 2.73$ in; $y = 1.42$ in

9-3. $I_x = 736$ in^4; $I_y = 256$ in^4; $I_{x'} = 136$ in^4

9-4. $I_x = 37.5 \times 10^6$ mm^4; $I_y = 53.7 \times 10^6$ mm^4

Shear Force and Bending Moment Diagrams

10-1. $N_C = 0$; $V_C = -1$ kip; $M_C = 56.0$ kip-ft; $N_D = 0$; $V_D = -1$ kip; $M_D = 48.0$ kip-ft

10-2. $N_B = 0$; $V_B = 28.8$ kip; $M_C = -115$ kip-ft

Flexural Loading – Bending Stresses in Beams

11-1. $\sigma_{max} = -2206$ psi; Max bending stress occurs at top surface

11-2. $\sigma_{max} = 281$ MPa; Max bending stress occurs at the base C, on outer surface of the pipe

11-3. $\sigma_B = -11.2$ MPa; $\sigma_D = 12.7$ MPa

11-4. $\sigma_{max} = -16.2$ MPa

Flexural Loading – Shear Stresses in Beams

12-1. $\tau_{max} = 1590$ psi; $\tau_{web} = 1240$ psi; $\tau_{flange} = 155$ psi

12-2. $\tau_{glue} = 4.88$ MPa

12-3. $(\sigma_{max})_T = 5198$ psi; $(\sigma_{max})_C = 3464$ psi; $\tau_F = 1082$ psi

Torsional Loading

13-1. $\tau_{out} = 345$ kPa; $\tau_{in} = 276$ kPa

13-2. $\tau_A = 18.9$ ksi; $\tau_B = 3.77$ ksi

13-3. $d_{min} = 0.858$ in. → 7/8 in.

13-4. $f = 26.6$ Hz

13-5. $s_P = 21.2$ mm

13-6. $\varphi = 0.085$ rad

Stress Transformation

14-1. $\sigma_1 = 80$ MPa; $\sigma_2 = -20$ MPa; $\theta_p = 26.6°$ (ccw)

14-2. $\sigma_1 = 1.67$ ksi; $\sigma_2 = -2.23$ ksi; $\tau_{max} = 1.95$ ksi

14-3. $\sigma_1 = 0.0723$ ksi; $\sigma_2 = -0.6833$ ksi