PROBLEM 4-1

Statement: **A differential stress element has a set of applied stresses on it as indicated in each row of Table P4-1. For the row(s) assigned, draw the stress element showing the applied stresses, find the principal stresses and maximum shear stress analytically and check the results by drawing Mohr's circles for that stress state.**

Solution: **See Table 4-1 for solution data to all rows of the problem statement. Only the variable sheet for row *j* is shown here. Also see the *TK*Solver file P04-01 which contains solutions for all rows. You may also run the program MOHR.EXE from the DOS partition of the CD-ROM supplied with the text and input the given data to see the Mohr's circles for any of the subsets (rows) of this problem.**

Table 4-1 Results for all rows of Problem 4-1

Row	σ_1	σ_2	σ_3	τ_{12}	τ_{23}	τ_{13}
a	1207	0	−207	604	104	707
b	401	0	−1401	201	701	901
c	1118	0	−1118	559	559	1118
d	311	0	−1811	155	905	1061
e	1059	0	−59	530	30	559
f	1311	0	−811	655	405	1061
g	1035	0	−785	518	393	910
h	1140	250	110	445	70	515
i	1383	−189	−1194	786	502	1289
j	1127	568	−1195	279	882	1161

PROBLEM 4-3

Statement: **For the bicycle pedal-arm assembly in Figure P4-1 with a rider-applied force of 1500 N at the pedal, determine the maximum principal stress in the pedal arm if its cross section is 15 mm in dia. The pedal attaches to the pedal arm with a 12-mm screw thread. What is the stress in the pedal screw?**

Solution: **Also see the *TK*Solver file P04-03.**

770	MPa	Max bending stress in pedal arm
531	MPa	Max bending stress in pedal screw
136	MPa	Max torsional shear stress in pedal ar
793	MPa	Max principal stress in pedal arm
0	MPa	principal stress in pedal arm
-23	MPa	principal stress in pedal arm
408	MPa	principal shear stress in pedal arm
396	MPa	principal shear stress in pedal arm
12	MPa	principal shear stress in pedal arm

PROBLEM 4-4

Statement: **The trailer hitch shown in Figure P4-2 and Figure 1-1 (p. 12) has loads applied as defined in Problem 3-4. The tongue weight of 100 kg acts downward and the pull force of 4 905 N acts horizontally. Using the dimensions of the ball bracket shown in Figure 1-5 (p. 15 of text), determine:**

114 MPa —(a) The principal stresses in the shank of the ball where it joins the ball bracket.

10 MPa —(b) The bearing stress in the ball bracket hole.

7 MPa —(c) The tearout stress in the ball bracket.

54 MPa —(d) The normal and shear stresses in the 19-mm dia attachment bolts,

73 MPa —(e) The principal stresses in the ball bracket as a cantilever.

Assumptions: **The nuts are only snug-tiaght (no preload) which is the worst case. All reactions are considered to be concentrated forces.**

PROBLEM 4-23

Statement: **A beam is supported and loaded as shown in Figure P4-11*a* Find the reactions, maximum shear, maximum moment, maximum slope, maximum bending stress, and maximum deflection for the data given in the assigned row(s) in Table P4-2.**

Solution: **See Table 4-23 for solution data to all rows of the problem statement. Only the variable sheet for row *a* is shown here. Also see the *TKSolver* file P04-23 which contains solutions for all rows.**

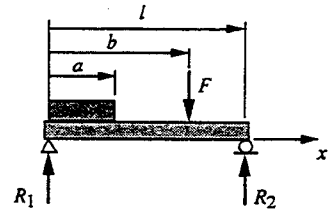

FIGURE 4-23A

Free Body Diagram for Problem 4-23

Table 4-23 Summary of results for all rows of Problem 4-23

param	R1	R2	Vmin	Vmax	Mmin	Mmax	tmin	tmax	ymin	ymax	stress
units	N	N	N	N	N-m	N-m	deg	deg	mm	mm	MPa
Row											
a	264	316	-316	264	0.0	126	-0.31	0.33	-1.82	0.00	88.7
b	378	488	-488	378	0.0	146	-0.40	0.44	-1.69	0.00	85.9
c	192	308	-308	192	0.0	31	-0.13	0.15	-0.24	0.00	81.2
d	85	198	-198	85	0.0	40	-0.41	0.54	-2.07	0.00	88.7
e	336	448	-448	336	0.0	156	-0.49	0.55	-2.53	0.00	78.1
f	256	775	-775	256	0.0	77	-0.20	0.28	-0.63	0.00	66.2
g	95	225	-225	95	0.0	22	-0.31	0.41	-1.11	0.00	52.5
h	205	335	-335	205	0.0	23	-0.22	0.26	-0.27	0.00	29.3
i	56	151	-151	56	0.0	15	-0.38	0.52	-0.98	0.00	27.5
j	31	64	-64	31	0.0	3	-0.19	0.24	-0.23	0.00	27.0
k	229	662	-662	229	0.0	66	-0.10	0.15	-0.27	0.00	22.3
l	86	536	-536	86	0.0	53	-0.18	0.30	-1.07	0.00	9.5
m	79	429	-429	79	0.0	43	-0.22	0.36	-1.03	0.00	13.2
n	29	100	-100	29	0.0	15	-0.27	0.40	-1.47	0.00	18.8

PROBLEM 4-24

Statement: **A beam is supported and loaded as shown in Figure P4-11*b*, find the reactions, the maximum shear, maximum moment, maximum slope, maximum bending stress, and maximum deflection for the data given in the assigned row(s) in Table P4-2.**

Solution: **See Table 4-24 for solution data to all rows of the problem statement. Only the variable sheet for row *a* is shown here. Also see the *TKSolver* file P04-24 which contains solutions for all rows.**

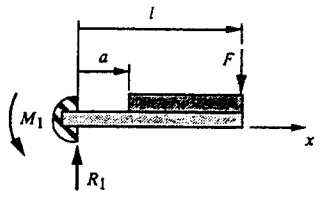

FIGURE 4-24A

Free Body Diagram for Problem 4-24

TABLE 4.24

	R1 N	M1 Nm	Vmin N	Vmax N	Mmax Nm		tmax deg	ymax mm	STRESS MPa
a	620	584	500	620	-584		-2.73	-32.2	410
b	890	613	850	890	-613		-3.46	-28.3	361
c	550	155	450	550	-155		-1.32	-4.7	412
d	270	213	0	270	-213		-4.76	-44.4	477
e	798	666	0	798	-666		-4.31	-42.7	333
f	1094	524	950	1094	-524		-3.02	-17.7	448
g	330	185	250	330	-185		-4.59	-32.6	434
h	540	106	0	540	-106		-2.11	-4.9	133
i	213	83	0	213	-83		-4.84	-22.6	152
j	95	18	0	95	-18		-2.20	-5.2	154
k	897	357	0	897	-357		-1.33	-6.2	120
l	659	574	0	659	-574		-4.87	-51.3	102
m	548	369	500	548	-369		-4.88	-39.9	114
n	162	123	0	162	-123		-5.05	-50.7	156

PROBLEM 4-33

Statement: For the bracket shown in Figure P4-14 and the data in the row(s) assigned from Table P4-3, determine the bending stress at point *A* and the shear stress due to transverse loading at point *B*. Also find the torsional shear stress at both points. Then determine the principal stresses at points *A* and *B*.

Solution: See Table 4-33 for solution data to all rows of the problem statement. Only the variable sheet for row *a* is shown here. Also see the *TK*Solver file P04-33 which contains solutions for all rows.

Table 4-33 Summary of results for all rows of Problem 4-33

param	σ x @A	τ bend @A	τ tors @A	σ 1 @A	σ 2 @A	σ 3 @A	τ max @A	σ 1 @B	σ 2 @B	σ 3 @B	τ max @B
units	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
Row											
a	8	0.6	16.8	21.5	0	-13.1	17	16.1	0	-16.1	16.1
b	8	0.6	10.9	15.4	0	-7.7	12	10.3	0	-10.3	10.3
c	24	0.7	3.9	24.3	0	-0.6	12	3.2	0	-3.2	3.2
d	14	0.2	4.4	15.4	0	-1.3	8	4.2	0	-4.2	4.2
e	5	0.9	10	12.7	0	-7.9	10	9.1	0	-9.1	9.1
f	4	1.5	8	10.5	0	-6.1	8	6.5	0	-6.5	6.5
g	16	1.3	13.7	23.7	0	-8	16	12.4	0	-12.4	12.4
h	29	2	7.3	31	0	-1.7	16	5.3	0	-5.3	5.3
i	16	0.8	3	16.3	0	-0.5	8	2.1	0	-2.1	2.1
j	18	1.5	4.5	19.1	0	-1.1	10	3	0	-3	3
k	8	1.6	6	11.2	0	-3.2	7	4.4	0	-4.4	4.4
l	9	1	7.4	13.1	0	-4.2	9	6.4	0	-6.4	6.4
m	15	3.2	10.5	20.2	0	-5.5	13	7.3	0	-7.3	7.3
n	11	1.5	10	17.1	0	-5.8	11	8.5	0	-8.5	8.5

PROBLEM 4-34

Statement: For the bracket shown in Figure P4-14 and the data in the row(s) assigned from Table P4-3, determine the deflection at load *F*.

Solution: See Table 4-34 for solution data to all rows of the problem statement. Only the variable sheet for row *a* is shown here. Also see the *TK*Solver file P04-34 which contains solutions for all rows.

Table 4-34 Deflection for all rows of Prob. 4-34

Row	y mm
a	−1.62
b	−0.20
c	−0.39
d	−5.43
e	−0.91
f	−0.97
g	−4.98
h	−7.91
i	−0.36
j	−11.57
k	−0.46
l	−0.55
m	−0.06
n	−0.12

PROBLEM 4-35

Statement: For the bracket shown in Figure P4-14 and the data in the row(s) assigned from Table P4-3, determine the spring rate of the tube in bending, the spring rate of the arm in bending and the spring rate of the tube in torsion. Combine these into an overall spring rate in terms of the force *F* and the linear deflection at force *F*.

Solution: See Table 4-35 for solution data to all rows of the problem statement. Only the variable sheet for row *a* is shown here. Also see the *TK*Solver file P04-35 which contains solutions for all rows.

Table 4-35 Results for all rows of Problem 4-35

Row	K N/mm
a	31
b	427
c	241
d	29.5
e	994
f	982
g	171
h	101
i	2658
j	51.9
k	1906
l	1357
m	8290
n	6795

PROBLEM 4-36

Statement: For the bracket shown in Figure P4-14 and the data in the row(s) assigned from Table P4-3, redo Problem 4-33 considering the stress concentration at points *A* and *B*. Assume a stress-concentration factor of 2.5 in both bending and torsion.

Solution: See Table 4-36 for solution data to all rows of the problem statement. Only the variable sheet for row *a* is shown here. Also see the *TK*Solver file P04-36 which contains solutions for all rows.

Table 4-36 Summary of results for all rows of Problem 4-36

param	σ x @A	τ bend @A	τ tors @A	σ 1 @A	σ 2 @A	σ 3 @A	τ max @A	σ 1 @B	σ 2 @B	σ 3 @B	τ max @B
units	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
Row											
a	8.40	0.60	16.8	21.5	0	−13.1	17	16.1	0	−16.1	16.0
b	7.60	0.60	10.9	15.4	0	−7.7	12	10.3	0	−10.3	10.0
c	23.60	0.70	3.9	24.3	0	−0.6	12	3.2	0	−3.2	3.0
d	14.10	0.20	4.4	15.4	0	−1.3	8	4.2	0	−4.2	4.0
e	4.90	0.90	10	12.7	0	−7.9	10	9.1	0	−9.1	9.0
f	4.40	1.50	8	10.5	0	−6.1	8	6.5	0	−6.5	6.0
g	15.70	1.30	13.7	23.7	0	−8	16	12.4	0	−12.4	12.0
h	29.30	2.00	7.3	31	0	−1.7	16	5.3	0	−5.3	5.0
i	15.70	0.80	3	16.3	0	−0.5	8	2.1	0	−2.1	2.0
j	18.00	1.50	4.5	19.1	0	−1.1	10	3	0	−3	3.0
k	8.00	1.60	6	11.2	0	−3.2	7	4.4	0	−4.4	4.0
l	8.90	1.00	7.4	13.1	0	−4.2	9	6.4	0	−6.4	6.0
m	14.80	3.20	10.5	20.2	0	−5.5	13	7.3	0	−7.3	7.0
n	11.30	1.50	10	17.1	0	−5.8	11	8.5	0	−8.5	8.0