

Level : B.E.

Year : II

Exam Roll No. :

Time: 30 mins.

Registration No.:

Course : MEEG 202

Semester : II

F. M. : 20

Date : 06 JUL 2023

SECTION "A"  
[20Q. × 1 = 20 marks]

Mark [X] in the most appropriate option.

1. A rod 10 mm × 10 mm cross-section is carrying an axial tensile load 10 kN. In this rod the tensile stress developed is \_\_\_\_\_.

$\sigma_t = 200$  MPa        $\sigma_t = 100$  MPa  
  $\sigma_t = 200$  GPa        $\sigma_t = 100$  GPa

2. Consider the Free body diagram as shown in Figure 1. Determine the Force component  $A_x$ .

40 kN                       80 kN  
 20 kN                       10 kN

3. An 18-m-long steel wire of 5-mm diameter is to be used in the manufacture of a pre-stressed concrete beam. It is observed that the wire stretches 45 mm when a tensile force P is applied. Knowing that  $E = 200$  GPa, determine

(a) the magnitude of the force P, (b) the corresponding normal stress in the wire.

12.82 kN, 600MPa                       9.82 kN, 500MPa  
 10.82 kN, 400MPa                       2.82 kN, 500MPa

4. The shear stress at a point in a shaft subjected to a torque is \_\_\_\_\_.

Directly proportional to the polar moment of inertia and to the distance of the point from the axis  
 Directly proportional to the applied torque and inversely proportional to the polar moment of inertia  
 Directly proportional to the applied torque and polar moment of inertia  
 Inversely proportional to the applied torque and the polar moment of inertia

5. In power transmission shafts, if the polar moment of inertia of a shaft is doubled, then what is the torque required to produce the same angle of twist?

1/4 of the original value                       1/2 of the original value  
 same as the original value                       Double the original value

6. What is Section Modulus of the Rectangular beam cross section?

$(1/4) bh^2$                         $(1/12) bh^2$                         $(1/6) bh^2$                         $(1/2) bh^2$

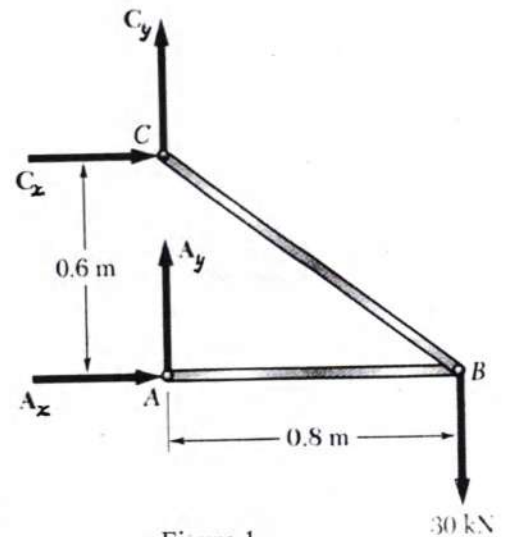


Figure 1

7. The principal stresses  $\sigma_1$ ,  $\sigma_2$  and  $\sigma_3$  at a point respectively are 80 MPa, 30 MPa and -40 MPa. The maximum shear stress is \_\_\_\_\_.
- 25 MPa       35 MPa       55 MPa       60 MPa
8. The second moment of a circular area about the diameter is given by \_\_\_\_\_. (D is the diameter)
- $\pi D^4 / 4$         $\pi D^4 / 16$         $\pi D^4 / 32$         $\pi D^4 / 64$
9. For a general two dimensional stress system, what are the coordinates of the centre of Mohr's circle?
- $(\sigma_x - \sigma_y / 2), 0$         $0, (\sigma_x + \sigma_y / 2)$   
  $(\sigma_x + \sigma_y / 2), 0$         $0, (\sigma_x - \sigma_y / 2)$

10. Consider the Mohr's circle shown in Figure 2  
 What is the state of stress represented by this circle?

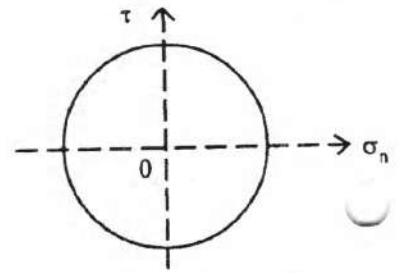


Figure 2

- $\sigma_x = \sigma_y \neq 0, \tau_{xy} = 0$   
  $\sigma_x + \sigma_y = 0, \tau_{xy} \neq 0$   
  $\sigma_x = 0, \sigma_y = \tau_{xy} \neq 0$   
  $\sigma_x \neq 0, \sigma_y = \tau_{xy} = 0$
11. For a circular shaft of diameter d subjected to torque T, the maximum value of the shear stress is \_\_\_\_\_.
- $64T / \pi d^3$         $32T / \pi d^3$         $16T / \pi d^3$         $8T / \pi d^3$
12. In I-Section of a beam subjected to transverse shear force, the maximum shear stress is developed at the \_\_\_\_\_.
- Centre of the web       top edge of the top flange  
 bottom edge of the top flange       side of the web
13. A simply supported beam of length 'l' is subjected to a symmetrical uniformly varying load with zero intensity at the ends and intensity w (load per unit length) at the mid span. What is the maximum bending moment?
- $3wl^2/8$         $wl^2/12$         $wl^2/24$         $5wl^2/12$
14. A simply supported beam is loaded as shown in the Figure 3. The maximum shear force in the beam will be \_\_\_\_\_.

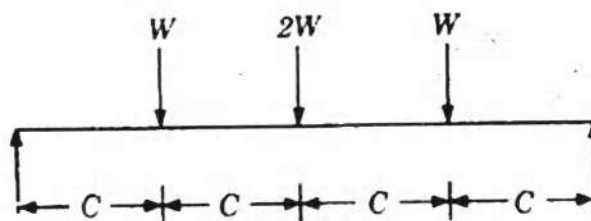


Figure 3

- Zero       W       2W       4W

15. In a cantilever beam, if the length is doubled while keeping the cross-section and the concentrated load acting at the free end the same, the deflection at the free end will increase by \_\_\_\_\_.
- 2.66 times       3 times       6 times       8 times
16. A lean elastic beam of given flexural rigidity,  $EI$ , is loaded by a single force  $F$  as shown in Figure 4. How many boundary conditions are necessary to determine the deflected center line of the beam as shown below?

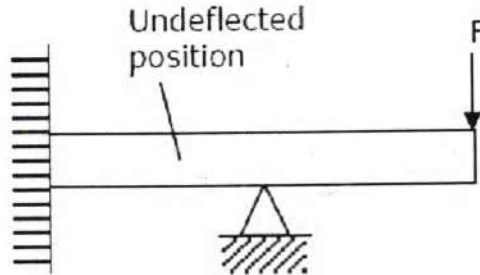
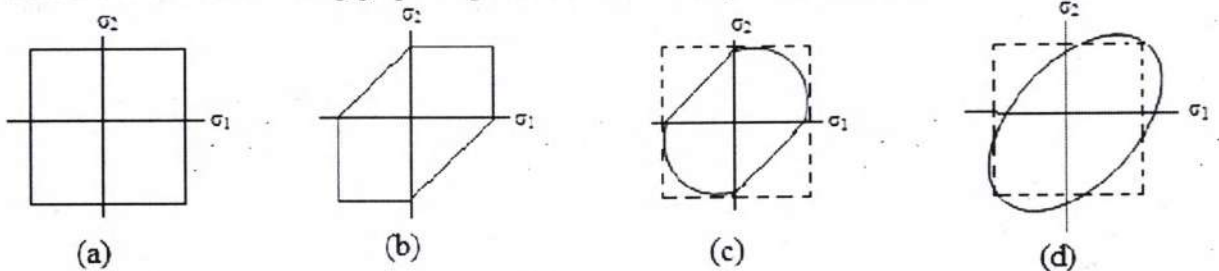


Figure 4

- 5       4       3       2
17. A pin-ended column of length  $L$ , modulus of elasticity  $E$  and second moment of the cross sectional area  $I$  is loaded centrally by a compressive load  $P$ . The critical buckling load ( $P_{cr}$ ) is given by \_\_\_\_\_.
- $P_{cr} = EI / \pi^2$         $P_{cr} = \pi^2 EI / 3L^2$         $P_{cr} = \pi EI / L^2$         $P_{cr} = \pi^2 EI / L^2$
18. Slenderness ratio of a column is defined as the ratio of its length to its \_\_\_\_\_.
- Least radius of gyration       Least lateral dimension  
 Maximum lateral dimension       Maximum radius of gyration
19. The maximum distortion energy theory of failure is suitable to predict the failure of \_\_\_\_\_ type of materials.
- Brittle       Ductile  
 Plastics       Composite
20. Which one of the following graphs represents Von Mises yield criterion?



- a       b       c       d

SECTION "B"

Attempt *ALL* questions. Assume suitable data if necessary.

- An aircraft tow bar is positioned by means of a single hydraulic cylinder connected by a 25-mm-diameter steel rod to two identical arm-and-wheel units DEF. The mass of the entire tow bar is 200 kg, and its center of gravity is located at G. For the position shown in Figure 1, determine the normal stress in the rod. [6]

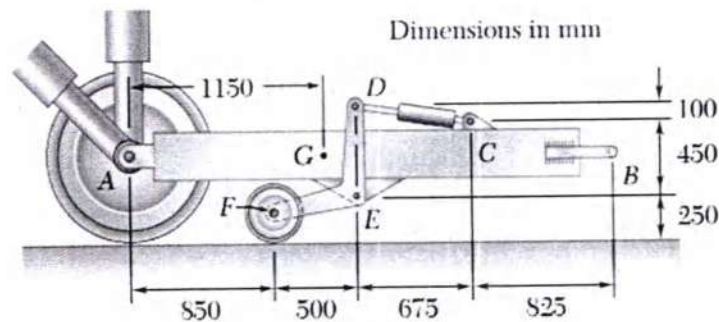


Figure 1

- A bar in the shape of a solid, truncated cone of circular cross section is situated between two rigid supports which constrain the bar from any change of axial length. The temperature of the entire bar is then raised to  $\Delta T$ . Assume that cross sections perpendicular to the longitudinal axis of symmetry remain plane and neglect localized end effects due to the end supports. Determine the normal stress at any point in the bar. [6]

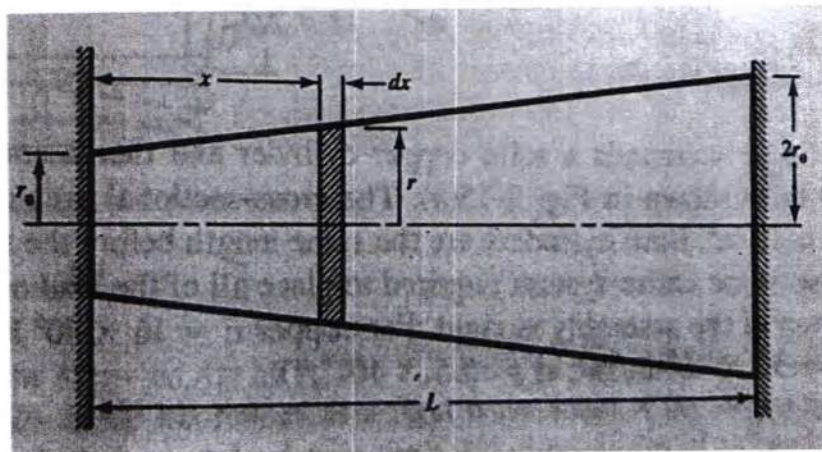


Figure 2

3. In medical (Orthopedic) applications it is occasionally necessary to lengthen a main bone of a human leg or arm. This situation may arise if the bone has healed in a wrong configuration after some accident, or alternatively the improper length may due to a birth defect. One way to accomplish this lengthening is for the surgeon to weaken the bone through the introduction of one or two cuts neat the outer surface of the bone, then attach the mechanical system as shown in the Figure 3 to the exterior of the leg. This system consists of a pair of metallic rings which encircle the leg, with the rings being connected by a pair of parallel brass rods which are threaded at each end. The distance between the rings can be varied over the months of treatment by turning the nut at each end of each rod. Typically, the bone has a cross-sectional area of  $774.192 \text{ mm}^2$  ( $1.2 \text{ in}^2$ ) a modulus of elasticity of  $31715.88355 \text{ N/mm}^2$  ( $4.6 \times 10^6 \text{ lb/in}^2$ ), and a length of 8 in. The two brass rods have a total cross-sectional area of  $32.258 \text{ mm}^2$  ( $0.05 \text{ in}^2$ ), a modulus of elasticity of  $93079.223456 \text{ N/mm}^2$  ( $13.5 \times 10^6 \text{ lb/in}^2$ ), and 32 threads (per  $25.4 \text{ mm} \cong \text{per inch}$ ). If the nut at the end of the bar is turned  $1/8$  of a revolution to stretch the bone, determine the axial stress arising in the bone. (Consider the system is assumed to be within the linear elastic range of action of the material.) [6]

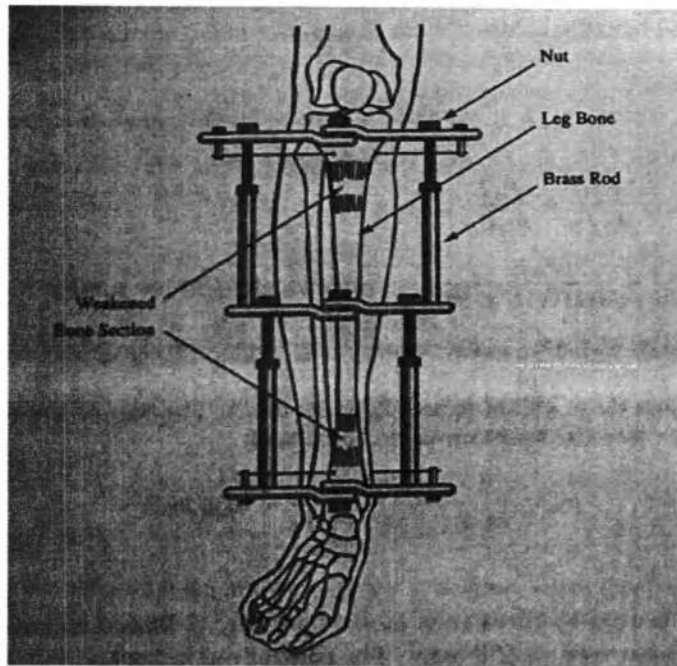


Figure 3

4. The W360 × 79 rolled-steel beam AC is simply supported and carries the uniformly distributed load shown in Figure 4. Draw the shear and bending-moment diagrams for the beam and determine the location and magnitude of the maximum normal stress due to bending. [5]

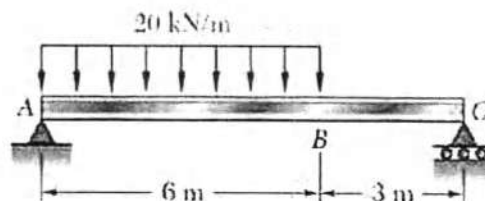


Figure 4

5. Shaft BC is hollow with inner and outer diameters of 90 mm and 120 mm, respectively. Shafts AB and CD are solid and of diameter  $d$ . For the loading shown, in Figure 5 determine (a) the maximum and minimum shearing stress in shaft BC, (b) the required diameter  $d$  of shafts AB and CD if the allowable shearing stress in these shafts is 65 MPa. [6]

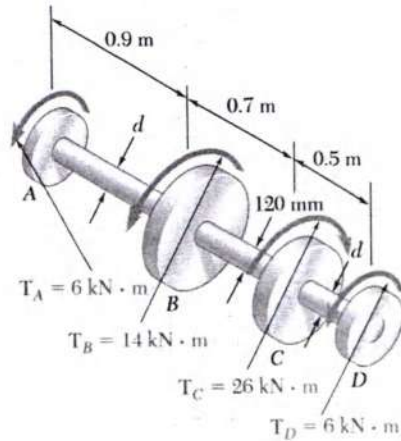


Figure 5

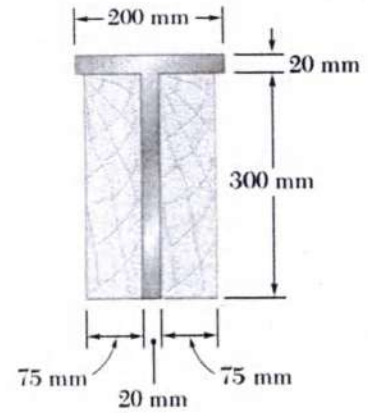


Figure 6

6. Two steel plates have been welded together to form a beam in the shape of a T that has been strengthened by securely bolting to it the two oak timbers shown in Figure 6. The modulus of elasticity is 12.5 GPa for the wood and 200 GPa for the steel. Knowing that a bending moment  $M = 50 \text{ kNm}$  is applied to the composite beam, determine [6]  
 a. the maximum stress in the wood,  
 b. the stress in the steel along the top edge.
7. The simply supported prismatic beam AB carries a uniformly distributed load  $w$  per unit length as shown in the Figure 7. Determine the equation of the elastic curve and the maximum deflection of the beam. [5]

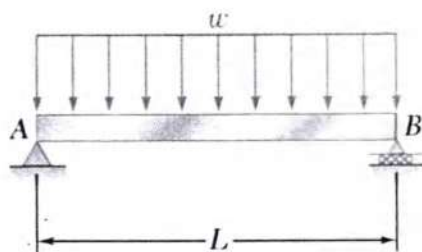


Figure 7

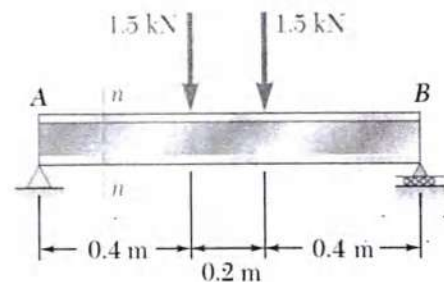


Figure 8

8. Beam AB is made of three planks glued together and is subjected, in its plane of symmetry, to the loading shown in Figure 8. Knowing that the width of each glued joint is 20 mm, determine the average shearing stress in each joint at section n-n of the beam. The location of the centroid of the section is given in the sketch and the centroidal moment of inertia is known to be  $I = 8.63 \times 10^{-6} \text{ m}^4$ . [5]

9. For the state of plane stress shown in Figure 9, determine [5]
- the principal planes,
  - the principal stresses,
  - the maximum shearing stress and the corresponding normal stress.

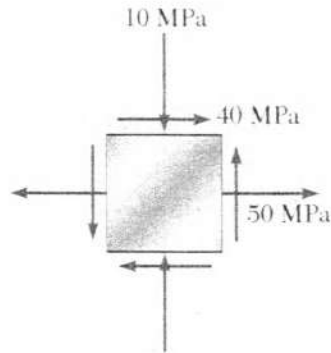


Figure 9

10. Explain in detail about Maximum Shear Stress (Tresca / Guests) Theory, mentioning the Region of Safety for safer design using Maximum Shear stress theory. [5]

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Table

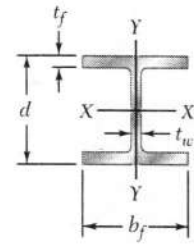
**APPENDIX B Typical Properties of Selected Materials Used in Engineering<sup>1,5</sup> A13**  
(SI Units)

Material	Density kg/m <sup>3</sup>	Ultimate Strength			Yield Strength <sup>3</sup>		Modulus of Elasticity, GPa	Modulus of Rigidity, GPa	Coefficient of Thermal Expansion, 10 <sup>-6</sup> /°C	Ductility, Percent Elongation in 50 mm
		Tension, MPa	Compres- sion, <sup>2</sup> MPa	Shear, MPa	Tension, MPa	Shear, MPa				
<b>Steel</b>										
Structural (ASTM-A36)	7860	400			250	145	200	77.2	11.7	21
High-strength-low-alloy										
ASTM-A709 Grade 345	7860	450			345		200	77.2	11.7	21
ASTM-A913 Grade 450	7860	550			450		200	77.2	11.7	17
ASTM-A992 Grade 345	7860	450			345		200	77.2	11.7	21
Quenched & tempered										
ASTM-A709 Grade 690	7860	760			690		200	77.2	11.7	18
<b>Stainless, AISI 302</b>										
Cold-rolled	7920	860			520		190	75	17.3	12
Annealed	7920	655			260	150	190	75	17.3	50
<b>Reinforcing Steel</b>										
Medium strength	7860	480			275		200	77	11.7	
High strength	7860	620			415		200	77	11.7	
<b>Cast Iron</b>										
Gray Cast Iron										
4.5% C, ASTM A-48	7200	170	655	240			69	28	12.1	0.5
Malleable Cast Iron										
2% C, 1% Si, ASTM A-47	7300	345	620	330	230		165	65	12.1	10
<b>Aluminum</b>										
Alloy 1100-H14										
(99% Al)	2710	110		70	95	55	70	26	23.6	9
Alloy 2014-T6	2800	455		275	400	230	75	27	23.0	13
Alloy-2024-T4	2800	470		280	325		73		23.2	19
Alloy-5456-H116	2630	315		185	230	130	72		23.9	16
Alloy 6061-T6	2710	260		165	240	140	70	26	23.6	17
Alloy 7075-T6	2800	570		330	500		72	28	23.6	11
<b>Copper</b>										
Oxygen-free copper										
(99.9% Cu)										
Annealed	8910	220		150	70		120	44	16.9	45
Hard-drawn	8910	390		200	265		120	44	16.9	4
<b>Yellow-Brass</b>										
(65% Cu, 35% Zn)										
Cold-rolled	8470	510		300	410	250	105	39	20.9	8
Annealed	8470	320		220	100	60	105	39	20.9	65
<b>Red Brass</b>										
(85% Cu, 15% Zn)										
Cold-rolled	8740	585		320	435		120	44	18.7	3
Annealed	8740	270		210	70		120	44	18.7	48
Tin bronze										
(88 Cu, 8Sn, 4Zn)	8800	310			145		95		18.0	30
Manganese bronze										
(63 Cu, 25 Zn, 6 Al, 3 Mn, 3 Fe)	8360	655			330		105		21.6	20
Aluminum bronze										
(81 Cu, 4 Ni, 4 Fe, 11 Al)	8330	620	900		275		110	42	16.2	6

(Table continued on page A14)

**APPENDIX C Properties of Rolled-Steel Shapes**  
(SI Units)

**W Shapes**  
(Wide-Flange Shapes)



Designation†	Area A, mm <sup>2</sup>	Depth d, mm	Flange		Web Thick- ness t <sub>w</sub> , mm	Axis X-X			Axis Y-Y		
			Width b <sub>f</sub> , mm	Thick- ness t <sub>f</sub> , mm		I <sub>x</sub> 10 <sup>6</sup> mm <sup>4</sup>	S <sub>x</sub> 10 <sup>3</sup> mm <sup>3</sup>	r <sub>x</sub> mm	I <sub>y</sub> 10 <sup>6</sup> mm <sup>4</sup>	S <sub>y</sub> 10 <sup>3</sup> mm <sup>3</sup>	r <sub>y</sub> mm
W920 × 449	57300	947	424	42.7	24.0	8780	18500	391	541	2560	97
201	25600	904	305	20.1	15.2	3250	7190	356	93.7	618	60.5
W840 × 299	38200	856	399	29.2	18.2	4830	11200	356	312	1560	90.4
176	22400	836	292	18.8	14.0	2460	5880	330	77.8	534	58.9
W760 × 257	32900	772	381	27.2	16.6	3430	8870	323	249	1310	86.9
147	18800	754	267	17.0	13.2	1660	4410	297	53.3	401	53.3
W690 × 217	27800	696	356	24.8	15.4	2360	6780	292	184	1040	81.3
125	16000	678	254	16.3	11.7	1190	3490	272	44.1	347	52.6
W610 × 155	19700	612	325	19.1	12.7	1290	4230	257	108	667	73.9
101	13000	602	228	14.9	10.5	762	2520	243	29.3	257	47.5
W530 × 150	19200	544	312	20.3	12.7	1010	3720	229	103	660	73.4
92	11800	533	209	15.6	10.2	554	2080	217	23.9	229	45.0
66	8390	526	165	11.4	8.89	351	1340	205	8.62	104	32.0
W460 × 158	20100	475	284	23.9	15.0	795	3340	199	91.6	646	67.6
113	14400	462	279	17.3	10.8	554	2390	196	63.3	452	66.3
74	9480	457	191	14.5	9.02	333	1460	187	16.7	175	41.9
52	6650	450	152	10.8	7.62	212	944	179	6.37	83.9	31.0
W410 × 114	14600	419	262	19.3	11.6	462	2200	178	57.4	441	62.7
85	10800	417	181	18.2	10.9	316	1510	171	17.9	198	40
60	7610	406	178	12.8	7.75	216	1060	168	12.0	135	39
46.1	5890	404	140	11.2	6.99	156	773	163	5.16	73.6	29.7
38.8	4950	399	140	8.76	6.35	125	629	159	3.99	57.2	28.4
W360 × 551	70300	455	419	67.6	42.2	2260	9950	180	828	3950	108
216	27500	376	394	27.7	17.3	712	3800	161	282	1430	101
122	15500	363	257	21.7	13.0	367	2020	154	61.6	480	63.0
101	12900	356	254	18.3	10.5	301	1690	153	50.4	397	62.5
79	10100	353	205	16.8	9.40	225	1270	150	24.0	234	48.8
64	8130	348	203	13.5	7.75	178	1030	148	18.8	185	48.0
57.8	7230	358	172	13.1	7.87	160	895	149	11.1	129	39.4
44	5710	351	171	9.78	6.86	121	688	146	8.16	95.4	37.8
39	4960	353	128	10.7	6.48	102	578	144	3.71	58.2	27.4
32.9	4190	348	127	8.51	5.84	82.8	475	141	2.91	45.9	26.4

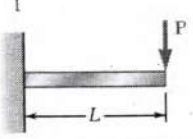
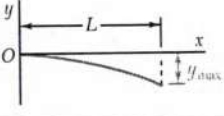
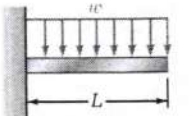
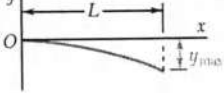
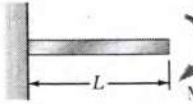
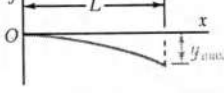
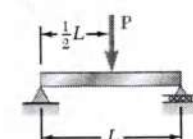
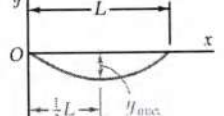
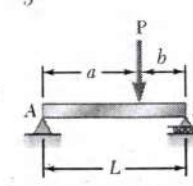
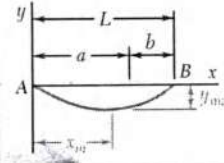
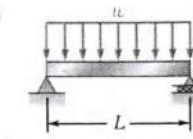
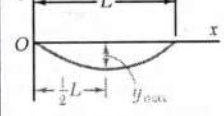
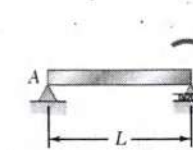
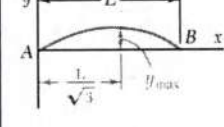
†A wide-flange shape is designated by the letter W followed by the nominal depth in millimeters and the mass in kilograms per meter.

(Table continued on page A18)

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APPENDIX D Beam Deflections and Slopes

Beam and Loading	Elastic Curve	Maximum Deflection	Slope at End	Equation of Elastic Curve
		$-\frac{PL^3}{3EI}$	$-\frac{PL^2}{2EI}$	$y = \frac{P}{6EI}(x^3 - 3Lx^2)$
		$-\frac{wL^4}{8EI}$	$-\frac{wL^3}{6EI}$	$y = -\frac{w}{24EI}(x^4 - 4Lx^3 + 6L^2x^2)$
		$-\frac{ML^2}{2EI}$	$-\frac{ML}{EI}$	$y = -\frac{M}{2EI}x^2$
		$\frac{PL^3}{48EI}$	$\pm \frac{PL^2}{16EI}$	<p>For <math>x \leq \frac{1}{2}L</math>:</p> $y = \frac{P}{48EI}(4x^3 - 3L^2x)$
		<p>For <math>a &gt; b</math>:</p> $\frac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}EIL}$ <p>at <math>x_m = \sqrt{\frac{L^2 - b^2}{3}}</math></p>	$\theta_A = -\frac{Pb(L^2 - b^2)}{6EIL}$ $\theta_B = +\frac{Pa(L^2 - a^2)}{6EIL}$	<p>For <math>x &lt; a</math>:</p> $y = \frac{Pb}{6EIL}[x^3 - (L^2 - b^2)x]$ <p>For <math>x = a</math>: <math>y = \frac{Pa^2b^2}{3EIL}</math></p>
		$-\frac{5wL^4}{384EI}$	$\pm \frac{wL^3}{24EI}$	$y = -\frac{w}{24EI}(x^4 - 2Lx^3 + L^3x)$
		$\frac{ML^2}{9\sqrt{3}EI}$	$\theta_A = +\frac{ML}{6EI}$ $\theta_B = -\frac{ML}{3EI}$	$y = -\frac{M}{6EIL}(x^3 - L^2x)$

