CONTENTS

Stress	2	1
1.3 Stress 40	21 f a Deformable Body 22 mal Stress in an Axially	
1.5 Average Shea1.6 Allowable Stree1.7 Limit State De	ess Design 64	

2 Strain 87 Chapter Objectives 87 2.1 Deformation 87

2.2 Strain 88

Mechanical Properties
of Materials 103

Chapter Objectives 103

3.1 The Tension and Compression Test 103

3.2 The Stress-Strain Diagram 105

3.3 Stress-Strain Behavior of Ductile and Brittle Materials 109

3.4 Strain Energy 113

3.5 Poisson's Ratio 124

3.6 The Shear Stress-Strain Diagram 126

*3.7 Failure of Materials Due to Creep and Fatigue 129

4	Axial Load 14			
	Chapter Objectives 141 Saint-Venant's Principle 141 Elastic Deformation of an Axially Loaded Member 143			
4.3	Principle of Superposition 158			
4.4	Statically Indeterminate Axially Loaded			
	Members 158			
4.5	The Force Method of Analysis for Axially			
	Loaded Members 165			
4.6	Thermal Stress 173			
4.7	Stress Concentrations 180			
*4.8	Inelastic Axial Deformation 183			
*4.9	Residual Stress 185			

5	Torsion 20°
5.1	Chapter Objectives 201 Torsional Deformation of a Circular Shaft 201
5.2	The Torsion Formula 204
5.3	Power Transmission 212
5.4	Angle of Twist 224
5.5	Statically Indeterminate Torque-Loaded
	Members 240
*5.6	Solid Noncircular Shafts 247
*5.7	Thin-Walled Tubes Having Closed Cross
	Sections 250
5.8	Stress Concentration 260
*5.9	Inelastic Torsion 263
*5.10	Residual Stress 265

8.2 State of Stress Caused by Combined

Loadings 438

6	Bending	281	9	Stress Transformation 4	463
6.1 6.2 6.3 6.4 6.5 *6.6 *6.7	Chapter Objectives 281 Shear and Moment Diagrams 281 Graphical Method for Constructing Stand Moment Diagrams 288 Bending Deformation of a Straight Member 307 The Flexure Formula 311 Unsymmetric Bending 328 Composite Beams 338 Reinforced Concrete Beams 341 Curved Beams 345	hear		Chapter Objectives 463 Plane-Stress Transformation 463 General Equations of Plane-Stress Transformation 468 Principal Stresses and Maximum In-Plan Shear Stress 471 Mohr's Circle—Plane Stress 487 Absolute Maximum Shear Stress 499	ıe
	Stress Concentrations 352 Inelastic Bending 362				
			10	Strain Transformation	511
7	Transverse Shear	385	10.1 10.2	Chapter Objectives 511 Plane Strain 511 General Equations of Plane-Strain Transformation 512	
7.1 7.2 7.3 7.4 *7.5	Chapter Objectives 385 Shear in Straight Members 385 The Shear Formula 386 Shear Flow in Built-Up Members 406 Shear Flow in Thin-Walled Members Shear Center for Open Thin-Walled		*10.4 10.5	Mohr's Circle—Plane Strain 520 Absolute Maximum Shear Strain 528 Strain Rosettes 530 Material Property Relationships 534 Theories of Failure 546	
	Members 418				
				Design of Beams and	
8	Combined Loadings	431	11	Shafts	563
8.1	Chapter Objectives 431 Thin-Walled Pressure Vessels 431		11.1 11.2	Chapter Objectives 563 Basis for Beam Design 563 Prismatic Beam Design 566	

***11.3** Fully Stressed Beams 580

***11.4** Shaft Design 584

19

12	Deflection of Beams and Shafts	595	14	Energy Methods	741
12.1 12.2 *12.3 *12.4 12.5 12.6 12.7 *12.8 12.9	Integration 599 Discontinuity Functions 617 Slope and Displacement by the Moment-Area Method 629 Method of Superposition 644 Statically Indeterminate Beams and Shafts 652 Statically Indeterminate Beams and Shafts—Method of Integration 653 Statically Indeterminate Beams and Shafts—Moment-Area Method 658	4	14.1 14.2 14.3 14.4 *14.5 *14.6 *14.7 *14.8 *14.9	Chapter Objectives 741 External Work and Strain Energy Elastic Strain Energy for Various Typ of Loading 746 Conservation of Energy 759 Impact Loading 766 Principle of Virtual Work 777 Method of Virtual Forces Applied to Trusses 780 Method of Virtual Forces Applied to Beams 788 Castigliano's Theorem 797 Castigliano's Theorem Applied to Trusses 799 Castigliano's Theorem Applied to Beams 802	
12.9	,	4	*14.10		

Chapter Objectives 683 Chapter Objectives 683 13.1 Critical Load 683 13.2 Ideal Column with Pin Supports 686 13.3 Columns Having Various Types of Supports 692 *13.4 The Secant Formula 704 *13.5 Inelastic Buckling 710 *13.6 Design of Columns for Concentric Loading 718 *13.7 Design of Columns for Eccentric Loading 728

Appendix

 A Geometric Properties of an Area 810
 B Geometric Properties of Structural Shapes 824

C Slopes and Deflections of Beams 829

Solutions and Answers for Preliminary Problems 831

Fundamental Problems Partial Solutions and Answers 841

Selected Answers 863

Index 883