



CONTENTS

1 INTRODUCTION TO MECHANICS OF MATERIALS

1

- 1.1 What Is Mechanics of Materials? 1
(Includes Color-Photo Insert)
- 1.2 The Fundamental Equations of
Deformable-Body Mechanics, 4
- 1.3 Problem-Solving Procedures, 6
- 1.4 Review of Static Equilibrium;
Equilibrium of Deformable Bodies, 8
- 1.5 Problems, 17

Chapter 1 Review, 21

2 STRESS AND STRAIN; INTRODUCTION TO DESIGN

22

- 2.1 Introduction, 22
- 2.2 Normal Stress, 23
- 2.3 Extensional Strain; Thermal Strain, 31
- 2.4 Stress-Strain Diagrams; Mechanical
Properties of Materials, 37
- 2.5 Elasticity and Plasticity; Temperature
Effects, 45
- 2.6 Linear Elasticity; Hooke's Law and
Poisson's Ratio, 48
- 2.7 Shear Stress and Shear Strain; Shear
Modulus, 51
- 2.8 Introduction to Design—Axial Loads
and Direct Shear, 57
- 2.9 Stresses on an Inclined Plane in an
Axially Loaded Member, 65

- 2.10 Saint-Venant's Principle, 67
- 2.11 Hooke's Law for Plane Stress; The
Relationship Between E and G , 69
- 2.12 General Definitions of Stress and Strain, 72
- *2.13 Cartesian Components of Stress;
Generalized Hooke's Law for Isotropic
Materials, 82
- *2.14 Mechanical Properties of Composite
Materials, 87
- 2.15 Problems, 89

Chapter 2 Review, 113

3 AXIAL DEFORMATION

118

- 3.1 Introduction, 118
- 3.2 Basic Theory of Axial Deformation, 118
- 3.3 Examples of Nonuniform Axial
Deformation, 126
- 3.4 Statically Determinate Structures, 136
- 3.5 Statically Indeterminate Structures, 143
- 3.6 Thermal Effects on Axial Deformation, 152
- 3.7 Geometric "Misfits," 163
- 3.8 Displacement-Method Solution of
Axial-Deformation Problems, 168
- *3.9 Force-Method Solution of Axial-
Deformation Problems, 180
- *3.10 Introduction to the Analysis of Planar
Trusses, 189
- *3.11 Inelastic Axial Deformation, 197
- 3.12 Problems, 209

Chapter 3 Review, 234

4 TORSION **237**

- 4.1 Introduction, 237
- 4.2 Torsional Deformation of Circular Bars, 238
- 4.3 Torsion of Linearly Elastic Circular Bars, 241
- 4.4 Stress Distribution in Circular Torsion Bars; Torsion Testing, 249
- 4.5 Statically Determinate Assemblages of Uniform Torsion Members, 253
- 4.6 Statically Indeterminate Assemblages of Uniform Torsion Members, 258
- 4.7 Displacement-Method Solution of Torsion Problems, 266
- 4.8 Power-Transmission Shafts, 272
- *4.9 Thin-Wall Torsion Members, 275
- *4.10 Torsion of Noncircular Prismatic Bars, 280
- *4.11 Inelastic Torsion of Circular Rods, 284
- 4.12 Problems, 290

Chapter 4 Review, 307

5 EQUILIBRIUM OF BEAMS **309**

- 5.1 Introduction, 309
- 5.2 Equilibrium of Beams Using Finite Free-Body Diagrams, 314
- 5.3 Equilibrium Relationships Among Loads, Shear Force, and Bending Moment, 318
- 5.4 Shear-Force and Bending-Moment Diagrams: Equilibrium Method 321
- 5.5 Shear-Force and Bending-Moment Diagrams: Graphical Method 326
- *5.6 Discontinuity Functions to Represent Loads, Shear, and Moment, 333
- 5.7 Problems, 340

Chapter 5 Review, 348

6 STRESSES IN BEAMS **351**

- 6.1 Introduction, 351
- 6.2 Strain-Displacement Analysis, 354
- 6.3 Flexural Stress in Linearly Elastic Beams, 360

- 6.4 Design of Beams for Strength, 369

- 6.5 Flexural Stress in Nonhomogeneous Beams, 375

- *6.6 Unsymmetric Bending, 383

- *6.7 Inelastic Bending of Beams, 392

- 6.8 Shear Stress and Shear Flow in Beams, 402

- 6.9 Limitations on the Shear-Stress Formula, 408

- 6.10 Shear Stress in Thin-Wall Beams, 411

- 6.11 Shear in Built-Up Beams, 421

- *6.12 Shear Center, 425

- 6.13 Problems, 432

Chapter 6 Review, 460

7 DEFLECTION OF BEAMS **463**

- 7.1 Introduction, 463

- 7.2 Differential Equations of the Deflection Curve, 464

- 7.3 Slope and Deflection by Integration—Statically Determinate Beams, 470

- 7.4 Slope and Deflection by Integration—Statically Indeterminate Beams, 483

- *7.5 Use of Discontinuity Functions to Determine Beam Deflections, 488

- 7.6 Slope and Deflection of Beams: Superposition Method, 495

- *7.7 Slope and Deflection of Beams: Displacement Method, 513

- 7.8 Problems, 520

Chapter 7 Review, 539

8 TRANSFORMATION OF STRESS AND STRAIN; MOHR'S CIRCLE **541**

- 8.1 Introduction, 541

- 8.2 Plane Stress, 542

- 8.3 Stress Transformation for Plane Stress, 544

- 8.4 Principal Stresses and Maximum Shear Stress, 551

- 8.5 Mohr's Circle for Plane Stress, 557

- 8.6 Triaxial Stress; Absolute Maximum Shear Stress, 564

- 8.7 Plane Strain, 571
- 8.8 Transformation of Strains in a Plane, 572
- 8.9 Mohr's Circle for Strain, 576
- 8.10 Measurement of Strain; Strain Rosettes, 582
- *8.11 Analysis of Three-Dimensional Strain, 587
- 8.12 Problems, 588

Chapter 8 Review, 601

- 11.4 Work-Energy Principle for Calculating Deflections, 697
- 11.5 Castigliano's Second Theorem; The Unit-Load Method, 702
- *11.6 Virtual Work, 713
- *11.7 Strain-Energy Methods, 717
- *11.8 Complementary-Energy Methods, 722
- *11.9 Dynamic Loading; Impact, 732
- 11.10 Problems, 737

Chapter 11 Review, 751

9 PRESSURE VESSELS; STRESSES DUE TO COMBINED LOADING 604

- 9.1 Introduction, 604
- 9.2 Thin-Wall Pressure Vessels, 605
- 9.3 Stress Distribution in Beams, 611
- 9.4 Stresses Due to Combined Loads, 616
- 9.5 Problems, 625

Chapter 9 Review, 633

12 SPECIAL TOPICS RELATED TO DESIGN 753

- 12.1 Introduction, 753
- 12.2 Stress Concentrations, 753
- *12.3 Failure Theories, 760
- *12.4 Fatigue and Fracture, 768
- 12.5 Problems, 772

Chapter 12 Review, 777

10 BUCKLING OF COLUMNS 635

- 10.1 Introduction, 635
- 10.2 The Ideal Pin-Ended Column; Euler Buckling Load, 638
- 10.3 The Effect of End Conditions on Column Buckling, 644
- *10.4 Eccentric Loading; The Secant Formula, 651
- *10.5 Imperfections in Columns, 657
- *10.6 Inelastic Buckling of Ideal Columns, 658
- 10.7 Design of Centrally Loaded Columns, 662
- 10.8 Problems, 668

Chapter 10 Review, 681

A NUMERICAL ACCURACY; APPROXIMATIONS A-1

- A.1 Numerical Accuracy; Significant Digits, A-1
- A.2 Approximations, A-2

B SYSTEMS OF UNITS B-1

- B.1 Introduction, B-1
- B.2 SI Units, B-1
- B.3 U.S. Customary Units; Conversion of Units, B-3

C GEOMETRIC PROPERTIES OF PLANE AREAS C-1

- C.1 First Moments of Area; Centroid, C-1
- C.2 Moments of Inertia of an Area, C-4
- C.3 Product of Inertia of an Area, C-8
- C.4 Area Moments of Inertia About Inclined Axes; Principal Moments of Inertia, C-10

11 ENERGY METHODS 683

- 11.1 Introduction, 683
- 11.2 Work and Strain Energy, 684
- 11.3 Elastic Strain Energy for Various Types of Loading, 691

**D SECTION PROPERTIES OF
SELECTED STRUCTURAL SHAPES****D-1**

- D.1 Properties of Steel Wide-Flange (W) Shapes (U.S. Customary Units), D-2**
- D.2 Properties of Steel Wide-Flange (W) Shapes (SI Units), D-3**
- D.3 Properties of American Standard (S) Beams (U.S. Customary Units), D-4**
- D.4 Properties of American Standard (C) Channels (U.S. Customary Units), D-5**
- D.5 Properties of Steel Angle Sections—Equal Legs (U.S. Customary Units), D-6**
- D.6 Properties of Steel Angle Sections—Unequal Legs (U.S. Customary Units), D-7**
- D.7 Properties of Standard-Weight Steel Pipe (U.S. Customary Units), D-8**
- D.8 Properties of Structural Lumber (U.S. Customary Units), D-9**
- D.9 Properties of Aluminum Association Standard I-Beams (U.S. Customary Units), D-10**
- D.10 Properties of Aluminum Association Standard Channels (U.S. Customary Units), D-11**

**E DEFLECTIONS AND SLOPES OF
BEAMS; FIXED-END ACTIONS****E-1**

- E.1 Deflections and Slopes of Cantilever Uniform Beams, E-1**

- E.2 Deflections and Slopes of Simply Supported Uniform Beams, E-3**
- E.3 Fixed-End Actions for Uniform Beams, E-4**

**F MECHANICAL PROPERTIES OF
SELECTED ENGINEERING MATERIALS****F-1**

- F.1 Specific Weight and Mass Density, F-2**
- F.2 Modulus of Elasticity, Shear Modulus of Elasticity, and Poisson's Ratio, F-3**
- F.3 Yield Strength, Ultimate Strength, Percent Elongation in 2 Inches, and Coefficient of Thermal Expansion, F-4**

G COMPUTATIONAL MECHANICS**G-1**

- G.1 MDSolids, G-1**

**ANSWERS TO SELECTED ODD-
NUMBERED PROBLEMS****ANS-1**

REFERENCES**R-1**

INDEX**I-1**
