Contents

Preface x
List of Symbols xv

1 Introduction 1

1.1 What Is Mechanics? 2
1.2 Fundamental Concepts and Principles 3
1.3 Systems of Units 6
1.4 Converting Between Two Systems of Units 10
1.5 Method of Solving Problems 12
1.6 Numerical Accuracy 15

2 Statics of Particles 17

Introduction 18
2.1 Addition of Planar Forces 18
2.2 Adding Forces by Components 29
2.3 Forces and Equilibrium in a Plane 38
2.4 Adding Forces in Space 52
2.5 Forces and Equilibrium in Space 64
Review and Summary 73
Review Problems 77

3 Rigid Bodies: Equivalent Systems of Forces 80

Introduction 81
3.1 Forces and Moments 82
3.2 Moment of a Force about an Axis 101
3.3 Couples and Force-Couple Systems 114
3.4 Simplifying Systems of Forces 131
Review and Summary 148
Review Problems 153

4 Equilibrium of Rigid Bodies 156

Introduction 157
4.1 Equilibrium in Two Dimensions 159
4.2 Two Special Cases 180
4.3 Equilibrium in Three Dimensions 187
4.4 Friction Forces 202
Review and Summary 219
Review Problems 223

5 Distributed Forces: Centroids and Centers of Gravity 227

Introduction 228
5.1 Planar Centers of Gravity and Centroids 228
5.2 Further Considerations of Centroids 244
5.3 Distributed Loads on Beams 255
5.4 Centers of Gravity and Centroids of Volumes 261
Review and Summary 272
Review Problems 275

6 Analysis of Structures 277

Introduction 278
6.1 Analysis of Trusses 279
6.2 Other Truss Analyses 291
6.3 Frames 305
6.4 Machines 317
Review and Summary 326
Review Problems 329

7 Distributed Forces: Moments of Inertia 332

Introduction 333
7.1 Moments of Inertia of Areas 333
7.2 Parallel-Axis Theorem and Composite Areas 342
Review and Summary 356
Review Problems 358

8 Concept of Stress 360

Introduction 361
8.1 Stresses in the Members of a Structure 361
8.2 Stress on an Oblique Plane Under Axial Loading 382
8.3 Stress Under General Loading Conditions; Components of Stress 383
8.4 Design Considerations 386
Review and Summary 404
Review Problems 407

9 Stress and Strain—Axial Loading 411

Introduction 412
9.1 Basic Principles of Stress and Strain 413
9.2 Statically Indeterminate Problems 433
9.3 Problems Involving Temperature Changes 437
9.4 Poisson's Ratio 452
9.5 Multiaxial Loading: Generalized Hooke's Law 453
9.6 Shearing Strain 455
***9.7** Deformations Under Axial Loading—Relation Between E, ν, and G 458
9.8 Stress and Strain Distribution Under Axial Loading: Saint-Venant's Principle 466
9.9 Stress Concentrations 468
Review and Summary 472
Review Problems 478

10 Torsion 481

Introduction 482
10.1 Circular Shafts in Torsion 483
10.2 Angle of Twist in the Elastic Range 502
10.3 Statically Indeterminate Shafts 505
Review and Summary 518
Review Problems 521

11 Pure Bending 524

Introduction 525
11.1 Symmetric Members in Pure Bending 527
11.2 Stresses and Deformations in the Elastic Range 531
11.3 Members Made of Composite Materials 548
11.4 Eccentric Axial Loading in a Plane of Symmetry 559
11.5 Unsymmetric Bending Analysis 569
11.6 General Case of Eccentric Axial Loading Analysis 574
Review and Summary 582
Review Problems 585

12 Analysis and Design of Beams for Bending 588

Introduction 589
12.1 Shear and Bending-Moment Diagrams 591
12.2 Relationships Between Load, Shear, and Bending Moment 603
12.3 Design of Prismatic Beams for Bending 617
Review and Summary 627
Review Problems 629

13 Shearing Stresses in Beams and Thin-Walled Members 631

Introduction 632
13.1 Horizontal Shearing Stress in Beams 634
13.2 Longitudinal Shear on a Beam Element of Arbitrary Shape 648
13.3 Shearing Stresses in Thin-Walled Members 650
Review and Summary 664
Review Problems 667

14 Transformations of Stress 669

Introduction 670
14.1 Transformation of Plane Stress 672
14.2 Mohr's Circle for Plane Stress 684

14.3 Stresses in Thin-Walled Pressure Vessels 694
Review and Summary 705
Review Problems 708

15 Deflection of Beams 710

Introduction 711
15.1 Deformation Under Transverse Loading 713
15.2 Statically Indeterminate Beams 722
15.3 Method of Superposition 738
Review and Summary 750
Review Problems 753

16 Columns 756

Introduction 757
16.1 Stability of Structures 757
16.2 Centric Load Design 777
Review and Summary 793
Review Problems 794

Appendices A1

A Reactions at Supports and Connections A2
B Centroids and Moments of Inertia of Common Geometric Shapes A4
C Typical Properties of Selected Materials Used in Engineering A6
D Properties of Rolled-Steel Shapes A10
E Beam Deflections and Slopes A22

Index I1
Answers to Problems AN1

*Advanced or specialty topics