

# STATICS AND MECHANICS OF MATERIALS

SIXTH EDITION IN SI UNITS

# CONTENTS



## 1 General Principles 31

Chapter Objectives 31

- 1.1 Mechanics 31
- 1.2 Fundamental Concepts 32
- 1.3 The International System of Units 36
- 1.4 Numerical Calculations 38
- 1.5 General Procedure for Analysis 40

## 2 Force Vectors 45

Chapter Objectives 45

- 2.1 Scalars and Vectors 45
- 2.2 Vector Operations 46
- 2.3 Vector Addition of Forces 48
- 2.4 Addition of a System of Coplanar Forces 58
- 2.5 Cartesian Vectors 67
- 2.6 Addition of Cartesian Vectors 70
- 2.7 Position Vectors 77
- 2.8 Force Vector Directed Along a Line 79
- 2.9 Dot Product 86



## 3 Force System Resultants 101

Chapter Objectives 101

- 3.1 Moment of a Force—Scalar Formulation 101
- 3.2 Principle of Moments 103
- 3.3 Cross Product 111
- 3.4 Moment of a Force—Vector Formulation 114
- 3.5 Moment of a Force about a Specified Axis 124
- 3.6 Moment of a Couple 132
- 3.7 Simplification of a Force and Couple System 142
- 3.8 Further Simplification of a Force and Couple System 152
- 3.9 Reduction of a Simple Distributed Loading 162

## 4 Equilibrium of a Rigid Body 175

Chapter Objectives 175

- 4.1 Conditions for Rigid-Body Equilibrium 175
- 4.2 Free-Body Diagrams 177
- 4.3 Equations of Equilibrium 186
- 4.4 Two- and Three-Force Members 192
- 4.5 Free-Body Diagrams 201
- 4.6 Equations of Equilibrium 206
- 4.7 Characteristics of Dry Friction 214
- 4.8 Problems Involving Dry Friction 219

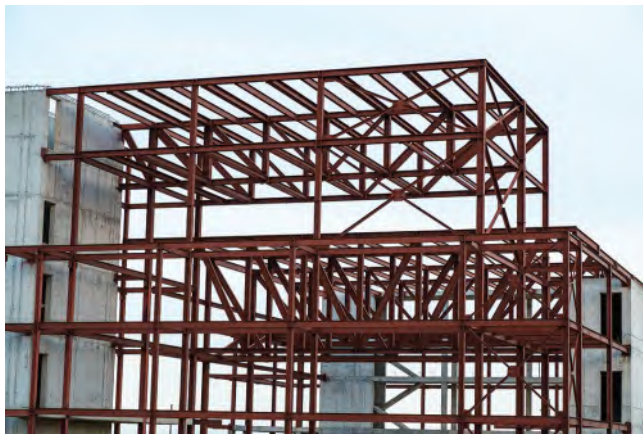




## 5 Structural Analysis 237

Chapter Objectives 237

- 5.1 Simple Trusses 237
- 5.2 The Method of Joints 240
- 5.3 Zero-Force Members 246
- 5.4 The Method of Sections 252
- 5.5 Frames and Machines 261



## 6 Center of Gravity, Centroid, and Moment of Inertia 285

Chapter Objectives 285

- 6.1 Center of Gravity and the Centroid of a Body 285
- 6.2 Composite Bodies 298
- 6.3 Moments of Inertia for Areas 306
- 6.4 Parallel-Axis Theorem for an Area 307
- 6.5 Moments of Inertia for Composite Areas 314



## 7 Stress and Strain 325

Chapter Objectives 325

- 7.1 Introduction 325
- 7.2 Internal Resultant Loadings 326
- 7.3 Stress 338
- 7.4 Average Normal Stress in an Axially Loaded Bar 340
- 7.5 Average Shear Stress 347
- 7.6 Allowable Stress Design 358
- 7.7 Deformation 373
- 7.8 Strain 374

## 8 Mechanical Properties of Materials 391

Chapter Objectives 391

- 8.1 The Tension and Compression Test 391
- 8.2 The Stress–Strain Diagram 393
- 8.3 Stress–Strain Behavior of Ductile and Brittle Materials 397
- 8.4 Strain Energy 401
- 8.5 Poisson’s Ratio 410
- 8.6 The Shear Stress–Strain Diagram 412





## 9

### Axial Load 423

Chapter Objectives 423

- 9.1 Saint-Venant's Principle 423
- 9.2 Elastic Displacement of an Axially Loaded Member 425
- 9.3 Principle of Superposition 438
- 9.4 Statically Indeterminate Axially Loaded Members 438
- 9.5 The Force Method of Analysis for Axially Loaded Members 445
- 9.6 Thermal Stress 451
- 9.7 Stress Concentrations 458



## 10

### Torsion 467

Chapter Objectives 467

- 10.1 Torsional Deformation of a Circular Shaft 467
- 10.2 The Torsion Formula 470
- 10.3 Power Transmission 478
- 10.4 Angle of Twist 488
- 10.5 Statically Indeterminate Torque-Loaded Members 502
- \*10.6 Solid Noncircular Shafts 509
- 10.7 Stress Concentration 512



## 11 Bending 523

Chapter Objectives 523

- 11.1 Internal Loading as a Function of Position 523
- 11.2 Graphical Method for Constructing Shear and Moment Diagrams 530
- 11.3 Bending Deformation of a Straight Member 547
- 11.4 The Flexure Formula 551
- 11.5 Unsymmetric Bending 564
- 11.6 Stress Concentrations 572

## 12 Transverse Shear 581

Chapter Objectives 581

- 12.1 Shear in Straight Members 581
- 12.2 The Shear Formula 582
- 12.3 Shear Flow in Built-Up Members 598



## 13 Combined Loadings 611

Chapter Objectives 611

- 13.1 Thin-Walled Pressure Vessels 611
- 13.2 State of Stress Caused by Combined Loadings 618

## 14 Stress and Strain Transformation 639

Chapter Objectives 639

- 14.1 Plane-Stress Transformation 639
- 14.2 General Equations of Plane Stress Transformation 644
- 14.3 Principal Stresses and Maximum In-Plane Shear Stress 647
- 14.4 Mohr's Circle—Plane Stress 659
- 14.5 Absolute Maximum Shear Stress 670
- 14.6 Plane Strain 675
- 14.7 General Equations of Plane-Strain Transformation 676
- 14.8 Mohr's Circle—Plane Strain 684
- \*14.9 Absolute Maximum Shear Strain 691
- 14.10 Strain Rosettes 693
- 14.11 Material Property Relationships 697





## 15 Design of Beams and Shafts 715

Chapter Objectives 715

- 15.1 Basis for Beam Design 715
- 15.2 Prismatic Beam Design 718



## 16 Deflection of Beams and Shafts 733

Chapter Objectives 733

- 16.1 The Elastic Curve 733
- 16.2 Slope and Displacement by Integration 737
- \* 16.3 Discontinuity Functions 753
- 16.4 Method of Superposition 764
- 16.5 Statically Indeterminate Beams and Shafts—Method of Superposition 772



## 17

### **Buckling of Columns** 789

Chapter Objectives 789

17.1 Critical Load 789

17.2 Ideal Column with Pin Supports 792

17.3 Columns Having Various Types of Supports 798

\*17.4 The Secant Formula 808

## **Appendices**

- A. Mathematical Review and Expressions 820
- B. Geometric Properties of an Area and Volume 824
- C. Geometric Properties of Structural Shapes 826
- D. Slopes and Deflections of Beams 828

## **Fundamental Problem Solutions** 830

## **Answers to Selected Problems** 865

## **Index** 879