### **ENGINEERING MECHANICS**

# STATICS

FIFTEENTH EDITION IN SI UNITS

## R. C. HIBBELER

SI Conversion by Jun Hwa Lee



### CONTENTS



#### 1 General Principles 25

Chapter Objectives 25

- 1.1 Mechanics 25
- **1.2** Fundamental Concepts 26
- **1.3** The International System of Units 29
- 1.4 Numerical Calculations 32
- **1.5** General Procedure for Analysis 34



### 2 Force Vectors 39

- 2.1 Scalars and Vectors 39
- 2.2 Vector Operations 40
- 2.3 Vector Addition of Forces 42
- 2.4 Addition of a System of Coplanar Forces 54
- 2.5 Cartesian Vectors 65
- 2.6 Addition of Cartesian Vectors 68
- 2.7 Position Vectors 76
- 2.8 Force Vector Directed Along a Line 78
- 2.9 Dot Product 86



### **3** Equilibrium of a Particle 103

Chapter Objectives 103

- **3.1** Condition for the Equilibrium of a Particle 103
- 3.2 The Free-Body Diagram 104
- 3.3 Coplanar Force Systems 107
- 3.4 Three-Dimensional Force Systems 120



#### 4 Force System Resultants 135

- **4.1** Moment of a Force—Scalar Formulation 135
- 4.2 Principle of Moments 137
- 4.3 Cross Product 145
- **4.4** Moment of a Force—Vector Formulation 148
- **4.5** Moment of a Force about a Specified Axis 158
- 4.6 Moment of a Couple 167
- **4.7** Simplification of a Force and Couple System 179
- **4.8** Further Simplification of a Force and Couple System 190
- **4.9** Reduction of a Simple Distributed Loading 202



### 5 Equilibrium of a Rigid Body 217

Chapter Objectives 217

- 5.1 Conditions for Rigid-Body Equilibrium 217
- 5.2 Free-Body Diagrams 219
- 5.3 Equations of Equilibrium 230
- 5.4 Two- and Three-Force Members 240
- 5.5 Free-Body Diagrams 253
- 5.6 Equations of Equilibrium 258
- 5.7 Constraints and Statical Determinacy 259



### 6

#### Structural Analysis 279

- 6.1 Simple Trusses 279
- 6.2 The Method of Joints 282
- 6.3 Zero-Force Members 288
- 6.4 The Method of Sections 296
- 6.5 Space Trusses 306
- 6.6 Frames and Machines 310



### 7 Internal Forces 347

Chapter Objectives 347

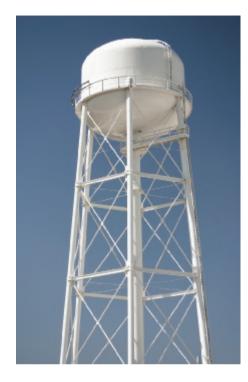
- 7.1 Internal Loadings 347
- **7.2** Shear and Moment Equations and Diagrams 363
- 7.3 Relations among Distributed Load, Shear, and Moment 372
- 7.4 Cables 383



### 8 Friction 403

- 8.1 Characteristics of Dry Friction 403
- 8.2 Problems Involving Dry Friction 408
- 8.3 Wedges 430
- 8.4 Frictional Forces on Screws 432
- 8.5 Frictional Forces on Flat Belts 439
- 8.6 Frictional Forces on Collar Bearings, Pivot Bearings, and Disks 447
- 8.7 Frictional Forces on Journal Bearings 450
- **8.8** Rolling Resistance 452

21



### **9** Center of Gravity and Centroid 465

Chapter Objectives 465

- **9.1** Center of Gravity, Center of Mass, and the Centroid of a Body 465
- 9.2 Composite Bodies 488
- 9.3 Theorems of Pappus and Guldinus 502
- 9.4 Resultant of a General Distributed Loading 511
- 9.5 Fluid Pressure 512



### 10 Moments of Inertia 529

- **10.1** Definition of Moments of Inertia for Areas 529
- **10.2** Parallel-Axis Theorem for an Area 530
- 10.3 Radius of Gyration of an Area 531
- **10.4** Moments of Inertia for Composite Areas 540
- 10.5 Product of Inertia for an Area 548
- **10.6** Moments of Inertia for an Area about Inclined Axes 552
- 10.7 Mohr's Circle for Moments of Inertia 555
- 10.8 Mass Moment of Inertia 563



### 11 Virtual Work 581

Chapter Objectives 581

- 11.1 Definition of Work 581
- 11.2 Principle of Virtual Work 583
- **11.3** Principle of Virtual Work for a System of Connected Rigid Bodies 585
- 11.4 Conservative Forces 597
- 11.5 Potential Energy 598
- **11.6** Potential-Energy Criterion for Equilibrium 600
- 11.7 Stability of Equilibrium Configuration 601

### Appendix

A. Mathematical Review and Formulations 616

Fundamental Problem Solutions and Answers 620

Review Problem Answers 637

Selected Answers 640

Index 653