Student's Preface xi Instructor's Preface xiii About the Authors xxi

CHAPTER 1 The Mechanical Engineering Profession 1

- 1.1 Overview 1

 The Elements of Mechanical Engineering 2
- 1.2 What Is Engineering? 4
- 1.3 Who Are Mechanical Engineers? 10

 Mechanical Engineering's Top Ten Achievements 11

 The Future of Mechanical Engineering 18
- 1.4 Career Paths 20
- 1.5 Typical Program of Study 22

Summary 26 Self-Study and Review 26 Problems 27 References 30

CHAPTER 2 Mechanical Design 31

- 2.1 Overview 31
- 2.2 The Design Process 35

 Requirements Development 39

 Conceptual Design 40

 Detailed Design 41

 Production 46
- 2.3 Manufacturing Processes 49

Summary 56 Self-Study and Review 57 Problems 57 References 62

CHAPTER 3 Technical Problem-Solving and Communication Skills 63

- 3.1 Overview 63
- 3.2 General Technical Problem-Solving Approach 68
- 3.3 Unit Systems and Conversions 69
 Base and Derived Units 70
 International System of Units 70
 United States Customary System of Units 73
 Converting Between the SI and USCS 77
- 3.4 Significant Digits 82
- 3.5 Dimensional Consistency 83
- 3.6 Estimation in Engineering 94
- 3.7 Communication Skills in Engineering 98
 Written Communication 99
 Graphical Communication 101
 Technical Presentations 102

Summary 107
Self-Study and Review 107
Problems 108
References 115

CHAPTER 4 Forces in Structures and Machines 116

- **4.1** Overview 116
- 4.2 Forces in Rectangular and Polar Forms 118
 Rectangular Components 119
 Polar Components 120
- 4.3 Resultant of Several Forces 121
 Vector Algebra Method 122
 Vector Polygon Method 123
- 4.4 Moment of a Force 127
 Perpendicular Lever Arm Method 128
 Moment Components Method 129
- 4.5 Equilibrium of Forces and Moments 135
 Particles and Rigid Bodies 135
 Free Body Diagrams 137
- 4.6 Design Application: Rolling-Element Bearings 145

Summary 153 Self-Study and Review 154 Problems 155 References 170

CHAPTER 5 Materials and Stresses 171

- **5.1** Overview 171
- 5.2 Tension and Compression 173
- 5.3 Material Response 182
- 5.4 Shear 193
- 5.5 Engineering Materials 198
 Metals and Their Alloys 199
 Ceramics 200
 Polymers 201
 Composite Materials 202
- 5.6 Factor of Safety 207

Summary 211 Self-Study and Review 213 Problems 214 References 226

CHAPTER 6 Fluids Engineering 227

- 6.1 Overview 227
- 6.2 Properties of Fluids 230
- 6.3 Pressure and Buoyancy Force 237
- 6.4 Laminar and Turbulent Fluid Flows 244
- 6.5 Fluid Flow in Pipes 248
- 6.6 Drag Force 254
- 6.7 Lift Force 264

Summary 270 Self-Study and Review 272 Problems 272 References 281

CHAPTER 7 Thermal and Energy Systems 282

- **7.1** Overview 282
- 7.2 Mechanical Energy, Work, and Power 284
 Gravitational Potential Energy 284
 Elastic Potential Energy 285

Kinetic Energy 285 Work of a Force 286 Power 286

7.3 Heat as Energy in Transit 291

Heating Value 292 Specific Heat 294 Transfer of Heat 295

7.4 Energy Conservation and Conversion 304

7.5 Heat Engines and Efficiency 308

7.6 Internal-Combustion Engines 313

Four-Stroke Engine Cycle 314 Two-Stroke Engine Cycle 317

7.7 Electrical Power Generation 319

Summary 329 Self-Study and Review 330 Problems 331 References 338

CHAPTER 8 Motion and Power Transmission 339

8.1 Overview 339

8.2 Rotational Motion 341

Angular Velocity 341 Rotational Work and Power 343

8.3 Design Application: Gears 348

Spur Gears 348
Rack and Pinion 352
Bevel Gears 353
Helical Gears 354
Worm Gearsets 355

8.4 Speed, Torque, and Power in Gearsets 357

Speed 357 Torque 359 Power 360

8.5 Simple and Compound Geartrains 360

Simple Geartrain 360 Compound Geartrain 362

8.6 Design Application: Belt and Chain Drives 368

8.7 Planetary Geartrains 374

Summary 382

Self-Study and Review 383 Problems 384 References 395

APPENDIX A Greek Alphabet 396 APPENDIX B Trigonometry Review 397

- **B.1** Degrees and Radians 397
- **B.2** Right Triangles 397
- **B.3** Identities 398
- **B.4** Oblique Triangles 399

INDEX 400