

Contents

Preface xiv

List of Symbols xxi

1

INTRODUCTION

1

- 1.1 What is Mechanics? 2
- 1.2 Fundamental Concepts and Principles 2
- 1.3 Systems of Units 5
- 1.4 Conversion from One system of Units to Another 10
- 1.5 Method of Problem Solution 11
- 1.6 Numerical Accuracy 13

2

STATICS OF PARTICLES

15

- 2.1 Introduction 16
 - Forces in a Plane 16**
- 2.2 Force on a Particle. Resultant of Two Forces 16
- 2.3 Vectors 17
- 2.4 Addition of Vectors 18
- 2.5 Resultant of Several Concurrent Forces 20
- 2.6 Resolution of a Force into Components 21
- 2.7 Rectangular Components of a Force. Unit Vectors 27
- 2.8 Addition of Forces by Summing x and y Components 30
- 2.9 Equilibrium of a Particle 35
- 2.10 Newton's First Law of Motion 36
- 2.11 Problems Involving the Equilibrium of a Particle.
Free-Body Diagrams 36
 - Forces in Space 45**
- 2.12 Rectangular Components of a Force in Space 45
- 2.13 Force Defined by Its Magnitude and Two Points on Its
Line of Action 48

2.14	Addition of Concurrent Forces in Space	49
2.15	Equilibrium of a Particle in Space	57
	Review and Summary for Chapter 2	64
	Review Problems	67
	Computer Problems	69

3

RIGID BODIES: EQUIVALENT SYSTEMS OF FORCES

73

3.1	Introduction	74
3.2	External and Internal Forces	74
3.3	Principle of Transmissibility. Equivalent Forces	75
3.4	Vector Product of Two Vectors	77
3.5	Vector Products Expressed in Terms of Rectangular Components	79
3.6	Moment of a Force about a Point	81
3.7	Varignon's Theorem	83
3.8	Rectangular Components of the Moment of a Force	83
3.9	Scalar Product of Two Vectors	93
3.10	Mixed Triple Product of Three Vectors	95
3.11	Moment of a Force about a Given Axis	97
3.12	Moment of a Couple	107
3.13	Equivalent Couples	108
3.14	Addition of Couples	110
3.15	Couples Can Be Represented by Vectors	110
3.16	Resolution of a Given Force Into a Force at O and a Couple	111
3.17	Reduction of a System of Forces to One Force and One Couple	122
3.18	Equivalent Systems of Forces	123
3.19	Equipollent Systems of Vectors	124
3.20	Further Reduction of a System of Forces	124
*3.21	Reduction of a System of Forces to a Wrench	127
	Review and Summary for Chapter 3	146
	Review Problems	151
	Computer Problems	153

4

EQUILIBRIUM OF RIGID BODIES

157

4.1	Introduction	158
4.2	Free-Body Diagram	159
	Equilibrium in Two Dimensions	160
4.3	Reactions at Supports and Connections for a Two-Dimensional Structure	160
4.4	Equilibrium of a Rigid Body in Two Dimensions	162
4.5	Statically Indeterminate Reactions. Partial Constraints	164
4.6	Equilibrium of a Two-Force Body	183
4.7	Equilibrium of a Three-Force Body	184
	Equilibrium in Three Dimensions	191
4.8	Equilibrium of a Rigid Body in Three Dimensions	191

Review and Summary for Chapter 4 211

Review Problems 213

Computer Problems 215

5

DISTRIBUTED FORCES: CENTROIDS AND CENTERS OF GRAVITY

219

5.1 Introduction 220

Areas and Lines 220

5.2 Center of Gravity of a Two-Dimensional Body 220

5.3 Centroids of Areas and Lines 222

5.4 First Moments of Areas and Lines 223

5.5 Composite Plates and Wires 226

5.6 Determination of Centroids by Integration 236

5.7 Theorems of Pappus-Guldinus 238

***5.8 Distributed Loads on Beams 248**

***5.9 Forces on Submerged Surfaces 249**

Volumes 259

5.10 Center of Gravity of a Three-Dimensional Body.

Centroid of a Volume 259

5.11 Composite Bodies 262

5.12 Determination of Centroids of Volumes by Integration 262

Review and Summary for Chapter 5 274

Review Problems 278

Computer Problems 281

6

ANALYSIS OF STRUCTURES

284

6.1 Introduction 285

Trusses 286

6.2 Definition of a Truss 286

6.3 Simple Trusses 288

6.4 Analysis of Trusses by the Method of Joints 289

***6.5 Joints under Special Loading Conditions 291**

***6.6 Space Trusses 293**

6.7 Analysis of Trusses by the Method of Sections 303

***6.8 Trusses Made of Several Simple Trusses 304**

Frames and Machines 315

6.9 Structures Containing Multiforce Members 315

6.10 Analysis of a Frame 315

6.11 Frames Which Cease to Be Rigid When Detached from Their Supports 316

6.12 Machines 331

Review and Summary for Chapter 6 343

Review Problems 346

Computer Problems 349

7

FORCES IN BEAMS AND CABLES

353

- *7.1 Introduction 354
- *7.2 Internal Forces in Members 354
- Beams 361**
- *7.3 Various Types of Loading and Support 361
- *7.4 Shear and Bending Moment in a Beam 362
- *7.5 Shear and Bending-Moment Diagrams 364
- *7.6 Relations among Load, Shear, and Bending Moment 372
- Cables 383**
- *7.7 Cables with Concentrated Loads 383
- *7.8 Cables with Distributed Loads 384
- *7.9 Parabolic Cable 385
- *7.10 Catenary 394
- Review and Summary for Chapter 7 402**
- Review Problems 405**
- Computer Problems 408**

8

FRICTION

411

- 8.1 Introduction 412
- 8.2 The Laws of Dry Friction. Coefficients of Friction 412
- 8.3 Angles of Friction 415
- 8.4 Problems Involving Dry Friction 416
- 8.5 Wedges 431
- 8.6 Square-Threaded Screws 431
- *8.7 Journal Bearings. Axle Friction 440
- *8.8 Thrust Bearings. Disk Friction 442
- *8.9 Wheel Friction. Rolling Resistance 443
- *8.10 Belt Friction 450
- Review and Summary for Chapter 8 461**
- Review Problems 464**
- Computer Problems 467**

9

DISTRIBUTED FORCES: MOMENTS OF INERTIA

471

- 9.1 Introduction 472
- Moments of Inertia of Areas 473**
- 9.2 Second Moment, or Moment of Inertia, of an Area 473
- 9.3 Determination of the Moment of Inertia of an Area by Integration 474
- 9.4 Polar Moment of Inertia 475
- 9.5 Radius of Gyration of an Area 476
- 9.6 Parallel-Axis Theorem 483
- 9.7 Moments of Inertia of Composite Areas 484
- *9.8 Product of Inertia 497
- *9.9 Principal Axes and Principal Moments of Inertia 498

*9.10	Mohr's Circle for Moments and Products of Inertia	506
	Moments of Inertia of Masses	512
9.11	Moment of Inertia of a Mass	512
9.12	Parallel-Axis Theorem	514
9.13	Moments of Inertia of Thin Plates	515
9.14	Determination of the Moment of Inertia of a Three-Dimensional Body by Integration	516
9.15	Moments of Inertia of Composite Bodies	516
*9.16	Moment of Inertia of a Body with Respect to an Arbitrary Axis through <i>O</i> . Mass Products of Inertia	531
*9.17	Ellipsoid of Inertia. Principal Axes of Inertia	532
*9.18	Determination of the Principal Axes and Principal Moments of Inertia of a Body of Arbitrary Shape	534
	Review and Summary for Chapter 9	545
	Review Problems	551
	Computer Problems	554

10

METHOD OF VIRTUAL WORK

557

*10.1	Introduction	558
*10.2	Work of a Force	558
*10.3	Principle of Virtual Work	561
*10.4	Applications of the Principle of Virtual Work	562
*10.5	Real Machines. Mechanical Efficiency	564
*10.6	Work of a Force during a Finite Displacement	578
*10.7	Potential Energy	580
*10.8	Potential Energy and Equilibrium	581
*10.9	Stability of Equilibrium	582
	Review and Summary for Chapter 10	592
	Review Problems	595
	Computer Problems	597

Appendix

FUNDAMENTALS OF ENGINEERING EXAMINATION

app-1

Photo Credits	<i>pc-1</i>
Index	<i>ind-1</i>
Answers to Problems	<i>ans-1</i>