

Contents

Preface xiv

List of Symbols xxi

11

KINEMATICS OF PARTICLES

601

- 11.1 Introduction to Dynamics 602
- Rectilinear Motion of Particles 603**
- 11.2 Position, Velocity, and Acceleration 603
- 11.3 Determination of the Motion of a Particle 607
- 11.4 Uniform Rectilinear Motion 616
- 11.5 Uniformly Accelerated Rectilinear Motion 617
- 11.6 Motion of Several Particles 618
- *11.7 Graphical Solution of Rectilinear-Motion Problems 630
- *11.8 Other Graphical Methods 631
- Curvilinear Motion of Particles 641**
- 11.9 Position Vector, Velocity, and Acceleration 641
- 11.10 Derivatives of Vector Functions 643
- 11.11 Rectangular Components of Velocity and Acceleration 645
- 11.12 Motion Relative to a Frame in Translation 646
- 11.13 Tangential and Normal Components 663
- 11.14 Radial and Transverse Components 666
- Review and Summary for Chapter 11 680**
- Review Problems 684**
- Computer Problems 687**

12

KINETICS OF PARTICLES: NEWTON'S SECOND LAW

691

- 12.1 Introduction 692
- 12.2 Newton's Second Law of Motion 693
- 12.3 Linear Momentum of a Particle. Rate of Change of Linear Momentum 694

12.4	Systems of Units	695
12.5	Equations of Motion	697
12.6	Dynamic Equilibrium	699
12.7	Angular Momentum of a Particle. Rate of Change of Angular Momentum	718
12.8	Equations of Motion in Terms of Radial and Transverse Components	719
12.9	Motion under a Central Force. Conservation of Angular Momentum	720
12.10	Newton's Law of Gravitation	721
*12.11	Trajectory of a Particle under a Central Force	731
*12.12	Application to Space Mechanics	732
*12.13	Kepler's Laws of Planetary Motion	735
	Review and Summary for Chapter 12	744
	Review Problems	784
	Computer Problems	751

13

KINETICS OF PARTICLES: ENERGY AND MOMENTUM METHODS

755

13.1	Introduction	756
13.2	Work of a Force	756
13.3	Kinetic Energy of a Particle. Principle of Work and Energy	760
13.4	Applications of the Principle of Work and Energy	762
13.5	Power and Efficiency	763
13.6	Potential Energy	781
*13.7	Conservative Forces	783
13.8	Conservation of Energy	784
13.9	Motion under a Conservative Central Force. Application to Space Mechanics	786
13.10	Principle of Impulse and Momentum	805
13.11	Impulsive Motion	808
13.12	Impact	820
13.13	Direct Central Impact	820
13.14	Oblique Central Impact	823
13.15	Problems Involving Energy and Momentum	826
	Review and Summary for Chapter 13	842
	Review Problems	848
	Computer Problems	851

14

SYSTEMS OF PARTICLES

855

14.1	Introduction	856
14.2	Application of Newton's Laws to the Motion of a System of Particles. Effective Forces	856
14.3	Linear and Angular Momentum of a System of Particles	859
14.4	Motion of the Mass Center of a System of Particles	860
14.5	Angular Momentum of a System of Particles about Its Mass Center	862

14.6	Conservation of Momentum for a System of Particles	864
14.7	Kinetic Energy of a System of Particles	873
14.8	Work-Energy Principle. Conservation of Energy for a System of Particles	875
14.9	Principle of Impulse and Momentum for a System of Particles	875
*14.10	Variable Systems of Particles	886
*14.11	Steady Stream of Particles	886
*14.12	Systems Gaining or Losing Mass	889
Review and Summary for Chapter 14		904
Review Problems		908
Computer Problems		911

15

KINEMATICS OF RIGID BODIES

915

15.1	Introduction	916
15.2	Translation	918
15.3	Rotation about a Fixed Axis	919
15.4	Equations Defining the Rotation of a Rigid Body about a Fixed Axis	922
15.5	General Plane Motion	932
15.6	Absolute and Relative Velocity in Plane Motion	934
15.7	Instantaneous Center of Rotation in Plane Motion	945
15.8	Absolute and Relative Acceleration in Plane Motion	956
*15.9	Analysis of Plane Motion in Terms of a Parameter	958
15.10	Rate of Change of a Vector with Respect to a Rotating Frame	971
15.11	Plane Motion of a Particle Relative to a Rotating Frame. Coriolis Acceleration	973
*15.12	Motion about a Fixed Point	984
*15.13	General Motion	987
*15.14	Three-Dimensional Motion of a Particle Relative to a Rotating Frame. Coriolis Acceleration	998
*15.15	Frame of Reference in General Motion	999
Review and Summary for Chapter 15		1011
Review Problems		1018
Computer Problems		1021

16

PLANE MOTION OF RIGID BODIES: FORCES AND ACCELERATIONS

1025

16.1	Introduction	1026
16.2	Equations of Motion for a Rigid Body	1027
16.3	Angular Momentum of a Rigid Body in Plane Motion	1028
16.4	Plane Motion of a Rigid Body. d'Alembert's Principle	1029
*16.5	A Remark on the Axioms of the Mechanics of Rigid Bodies	1030
16.6	Solution of Problems Involving the Motion of a Rigid Body	1031
16.7	Systems of Rigid Bodies	1032

16.8	Constrained Plane Motion	1051
-------------	--------------------------	------

Review and Summary for Chapter 16	1073
------------------------------------------	-------------

Review Problems	1075
------------------------	-------------

Computer Problems	1078
--------------------------	-------------

17

PLANE MOTION OF RIGID BODIES: ENERGY AND MOMENTUM METHODS

1081

17.1	Introduction	1082
17.2	Principle of Work and Energy for a Rigid Body	1082
17.3	Work of Forces Acting on a Rigid Body	1083
17.4	Kinetic Energy of a Rigid Body in Plane Motion	1084
17.5	Systems of Rigid Bodies	1085
17.6	Conservation of Energy	1086
17.7	Power	1087
17.8	Principle of Impulse and Momentum for the Plane Motion of a Rigid Body	1104
17.9	Systems of Rigid Bodies	1107
17.10	Conservation of Angular Momentum	1107
17.11	Impulsive Motion	1120
17.12	Eccentric Impact	1120

Review and Summary for Chapter 17	1134
------------------------------------------	-------------

Review Problems	1138
------------------------	-------------

Computer Problems	1141
--------------------------	-------------

18

KINETICS OF RIGID BODIES IN THREE DIMENSIONS

1145

*18.1	Introduction	1146
*18.2	Angular Momentum of a Rigid Body in Three Dimensions	1147
*18.3	Application of the Principle of Impulse and Momentum to the Three-Dimensional Motion of a Rigid Body	1151
*18.4	Kinetic Energy of a Rigid Body in Three Dimensions	1152
*18.5	Motion of a Rigid Body in Three Dimensions	1165
*18.6	Euler's Equations of Motion. Extension of d'Alembert's Principle to the Motion of a Rigid Body in Three Dimensions	1166
*18.7	Motion of a Rigid Body about a Fixed Point	1167
*18.8	Rotation of a Rigid Body about a Fixed Axis	1168
*18.9	Motion of a Gyroscope. Eulerian Angles	1183
*18.10	Steady Precession of a Gyroscope	1185
*18.11	Motion of an Axisymmetrical Body under No Force	1186

Review and Summary for Chapter 18	1199
------------------------------------------	-------------

Review Problems	1204
------------------------	-------------

Computer Problems	1208
--------------------------	-------------

19**MECHANICAL VIBRATIONS**

1213

- 19.1** Introduction 1214
- Vibrations without Damping 1214**
- 19.2** Free Vibrations of Particles. Simple Harmonic Motion 1214
- 19.3** Simple Pendulum (Approximate Solution) 1218
- *19.4** Simple Pendulum (Exact Solution) 1219
- 19.5** Free Vibrations of Rigid Bodies 1228
- 19.6** Application of the Principle of Conservation of Energy 1240
- 19.7** Forced Vibrations 1251
- Damped Vibrations 1261**
- *19.8** Damped Free Vibrations 1261
- *19.9** Damped Forced Vibrations 1264
- *19.10** Electrical Analogues 1265
- Review and Summary for Chapter 19 1277**
- Review Problems 1282**
- Computer Problems 1285**

Appendix**FUNDAMENTALS OF ENGINEERING EXAMINATION***app-1***Photo Credits** *pc-1***Index** *ind-1***Answers to Problems** *ans-1*