

Contents

12. Kinematics of a Particle	1
12-1 Introductory Remarks, Kinematics of Particles	1
12-2 Rectilinear Velocity and Acceleration of a Particle	2
12-3 Graphical Solutions	12
12-4 Curvilinear Velocity and Acceleration of a Particle	22
12-5 Curvilinear Motion of a Particle:	
Rectangular Components	25
12-6 Motion of a Projectile	29
12-7 Curvilinear Motion of a Particle:	
Cylindrical Components	37
12-8 Curvilinear Motion of a Particle: Normal and	
Tangential Components	50
12-9 Absolute-Dependent-Motion Analysis of Two Particles	58
12-10 Relative-Motion Analysis of Two Particles	
Using Translating Axes	63
13. Kinetics of a Particle:	
Forces and Accelerations	75
13-1 Newton's Laws of Motion	75
13-2 The Equation of Motion	78
13-3 Equation of Motion for a System of Particles	79
13-4 Equations of Motion for a Particle:	
Rectangular Coordinates	80
13-5 Equations of Motion for a Particle:	
Cylindrical Coordinates	94

13-6	Equations of Motion for a Particle: Normal and Tangential Coordinates	102
*13-7	Central-Force Motion and Space Mechanics	112
14. Kinetics of a Particle: Work and Energy		123
14-1	The Work of a Force	123
14-2	Principle of Work and Energy	128
14-3	Principle of Work and Energy for a System of Particles	130
14-4	Power and Efficiency	140
14-5	Conservative Forces and Potential Energy	147
14-6	Conservation-of-Energy Theorem	151
15. Kinetics of a Particle: Impulse and Momentum		163
15-1	Principle of Linear Impulse and Momentum for a Particle	163
15-2	Principle of Linear Impulse and Momentum for a System of Particles	172
15-3	Conservation of Linear Momentum for a System of Particles	174
15-4	Impact	185
15-5	Angular Momentum of a Particle	198
15-6	Angular Momentum of a System of Particles	200
15-7	Angular Impulse and Momentum Principles for a Particle	201
*15-8	Steady Fluid Streams	211
*15-9	Propulsion with Variable Mass	216
16. Planar Kinematics of a Rigid Body		227
16-1	Rigid-Body Motion	227
16-2	Translation of a Rigid Body	229
16-3	Rotation of a Rigid Body About a Fixed Axis	230
16-4	Absolute-General-Plane-Motion Analysis of a Rigid Body	241
16-5	Relative-General-Plane-Motion Analysis of a Rigid Body Using Translating Axes. Velocity	246
16-6	Method for Determining Velocity Using Cartesian Vectors	252
16-7	Instantaneous Center of Zero Velocity	260

16-8	Relative-General-Plane-Motion Analysis of a Rigid Body Using Translating Axes. Acceleration	266
16-9	Method for Determining Acceleration Using Cartesian Vectors	276
16-10	Relative-General-Plane-Motion Analysis of a Particle or Rigid Body Using Translating and Rotating Axes	284
17. Planar Kinetics of Rigid Bodies: Forces and Accelerations		299
17-1	Introduction	299
17-2	Mass Moment of Inertia	299
17-3	Planar Kinetic Equations of Motion	312
17-4	Equations of Motion: Translation of a Rigid Body	315
17-5	Equations of Motion: Rotation of a Rigid Body About a Fixed Axis	328
17-6	Equations of Motion: General Plane Motion of a Rigid Body	345
18. Planar Kinetics of Rigid Bodies: Work and Energy		359
18-1	Kinetic Energy of a Rigid Body	359
18-2	The Work of a Force	363
18-3	The Work of a Couple	366
18-4	Principle of Work and Energy	367
18-5	Conservation of Energy	379
19. Planar Kinetics of Rigid Bodies: Impulse and Momentum		391
19-1	Linear and Angular Momentum of a Rigid Body	391
19-2	Principle of Impulse and Momentum for a Rigid Body	394
19-3	Conservation of Momentum	411
20. Spatial Kinematics of a Rigid Body		421
20-1	Introduction	421
20-2	Rotation of a Rigid Body About a Fixed Point	421

20-3	The Time Derivative of a Vector Measured from a Fixed and Translating-Rotating System	425
20-4	Euler Angles	431
20-5	General Motion of a Rigid Body	435
20-6	Relative-Motion Analysis Using Translating and Rotating Axes	444
 21. Spatial Kinetics of a Rigid Body		 457
*21-1	Introduction	457
*21-2	Mass Moments and Products of Inertia	457
21-3	Angular Momentum of a Rigid Body	468
21-4	Kinetic Energy of a Rigid Body	471
*21-5	Equations of Motion of a Rigid Body	482
*21-6	Gyroscopic Motion	499
*21-7	Torque-Free Motion	504
 22. Vibrations		 513
22-1	Simple Harmonic Motion	513
22-2	Undamped Free Vibration	517
22-3	Energy Methods	528
22-4	Undamped Forced Vibration	536
22-5	Viscous Damped Free Vibration	543
*22-6	Viscous Damped Forced Vibration	547
*22-7	Electrical Circuit Analogues	549
 Appendix A. Units of Measurement		 555
Appendix B. Vector Analysis		561
Appendix C. Mathematical Expressions		567
Appendix D. Moments and Products of Inertia of Homogeneous Solids		571
Answers		575
Index		587