

CONTENTS

Chapter 1. Kinematics of Particles	1
1. Introduction	1
2. Definition and Description of Particles.	6
3. Velocity.	11
4. Acceleration	12
5. Special Coordinate Systems	13
6. Vector Algebra.	16
7. Kinematics and Measurement	22
Exercises	25
Chapter 2. The Laws of Motion	27
8. Mass	27
9. Momentum and Force	28
10. Kinetic Energy	31
11. Potential Energy	32
12. Conservation of Energy	35
13. Angular Momentum	36
14. Rigid Body Rotating about a Fixed Point	38
15. A Theorem on Quadratic Functions.	40
16. Inertial and Gravitational Masses	43
Exercises	44
Chapter 3. Conservative Systems with One Degree of Freedom	47
17. The Oscillator	47
18. The Plane Pendulum	50
19. Child-Langmuir Law	54
Exercises	56

Chapter 4. Two-Particle Systems	58
20. Introduction	58
21. Reduced Mass	59
22. Relative Kinetic Energy	61
23. Laboratory and Center-of-Mass Systems	62
24. Central Motion	63
Exercises	65
Chapter 5. Time-Dependent Forces and Nonconservative Motion	66
25. Introduction	66
26. The Inverted Pendulum	67
27. Rocket Motion.	70
28. Atmospheric Drag.	71
29. The Poynting-Robertson Effect	73
30. The Damped Oscillator	74
Exercises	76
Chapter 6. Lagrange's Equations of Motion	77
31. Derivation of Lagrange's Equations.	77
32. The Lagrangian Function	81
33. The Jacobian Integral	82
34. Momentum Integrals	83
35. Charged Particle in an Electromagnetic Field	85
Exercises	88
Chapter 7. Applications of Lagrange's Equations	90
36. Orbits under a Central Force	90
37. Kepler Motion.	93
38. Rutherford Scattering.	100
39. The Spherical Pendulum	103
40. Larmor's Theorem.	107
41. The Cylindrical Magnetron	110
Exercises	111
Chapter 8. Small Oscillations	113
42. Oscillations of a Natural System	113
43. Systems with Few Degrees of Freedom.	117
44. The Stretched String, Discrete Masses	124

CONTENTS	ix
45. Reduction of the Number of Degrees of Freedom	129
46. Laplace Transforms and Dissipative Systems	131
Exercises	134
Chapter 9. Rigid Bodies	136
47. Displacements of a Rigid Body	136
48. Euler's Angles	140
49. Kinematics of Rotation	141
50. The Momental Ellipsoid	146
51. The Free Rotator	148
52. Euler's Equations of Motion	149
Exercises	152
Chapter 10. Hamiltonian Theory	154
53. Hamilton's Equations	154
54. Hamilton's Equations in Various Coordinate Systems	159
55. Charged Particle in an Electromagnetic Field	162
56. The Virial Theorem	164
57. Variational Principles	166
58. Contact Transformations	172
59. Alternative Forms of Contact Transformations	177
60. Alternative Forms of the Equations of Motion	179
Exercises	181
Chapter 11. The Hamilton-Jacobi Method	183
61. The Hamilton-Jacobi Equation	183
62. Action and Angle Variables—Periodic Systems	188
63. Separable Multiply-Periodic Systems	196
64. Applications	200
Exercises	213
Chapter 12. Infinitesimal Contact Transformations	215
65. Transformation Theory of Classical Dynamics	215
66. Poisson Brackets	220
67. Jacobi's Identity	228
68. Poisson Brackets in Quantum Mechanics	230
Exercises	231

x	CONTENTS	
Chapter 13. Further Development of Transformation Theory		232
69.	Notation	232
70.	Integral Invariants and Liouville's Theorem	233
71.	Lagrange Brackets	237
72.	Change of Independent Variable	238
73.	Extended Contact Transformations	241
74.	Perturbation Theory	244
75.	Stationary State Perturbation Theory	245
76.	Time-Dependent Perturbation Theory	251
77.	Quasi Coordinates and Quasi Momenta	254
	Exercises	257
Chapter 14. Special Applications		258
78.	Noncentral Forces.	258
79.	Spin Motion	262
80.	Variational Principles in Rocket Motion	265
81.	The Boltzmann and Navier-Stokes Equations.	268
Chapter 15. Continuous Media and Fields		273
82.	The Stretched String	273
83.	Energy-Momentum Relations	277
84.	Three-Dimensional Media and Fields	280
85.	Hamiltonian Form of Field Theory	284
	Exercises	286
Chapter 16. Introduction to Special Relativity Theory		287
86.	Introduction	287
87.	Space-Time and the Lorentz Transformation	288
88.	The Motion of a Free Particle	294
89.	Charged Particle in an Electromagnetic Field.	296
90.	Hamiltonian Formulation of the Equations of Motion	298
91.	Transformation Theory and the Lorentz Group	302
92.	Thomas Precession	304
	Exercises	312
Chapter 17. The Orbits of Particles in High Energy Accelerators		314
93.	Introduction	314
94.	Equilibrium Orbits	315

	CONTENTS	xi
95. Betatron Oscillations	318	
96. Weak Focusing Accelerators	323	
97. Strong Focusing Accelerators	324	
98. Acceleration and Synchrotron Oscillations.	329	
Appendix I Riemannian Geometry	335	
Appendix II Linear Vector Spaces	345	
Appendix III Group Theory and Molecular Vibrations	364	
Appendix IV Quaternions and Pauli Spin Matrices	373	
Index	383	