

## CONTENTS

Preface	v
CHAPTER I NEWTON'S LAWS	1
Newton's laws	1
Free fall	3
Simple harmonic oscillator	4
Central force	6
Gravitational force: qualitative	9
Gravitational force: quantitative	11
Parameters of earth's orbit	16
Scattering	19
Coulomb scattering	21
Exercises	22
CHAPTER II THE PRINCIPLE OF VIRTUAL WORK AND D'ALEMBERT'S PRINCIPLE	28
Constraints	28
Principle of virtual work	29
D'Alembert's principle and generalized coordinates	32
Lever	33
Inclined plane	34
Plane pendulum	34
Exercises	37
CHAPTER III LAGRANGE'S EQUATIONS	40
Lagrange's equations	40
Plane pendulum	44
Spherical pendulum	45
Electromagnetic interaction	46
Interaction of an electric charge and a magnet	49
Exercises	54

CHAPTER IV	THE PRINCIPLE OF STATIONARY ACTION OR HAMILTON'S PRINCIPLE	59
	Principle of stationary action	59
	Calculus of variations	62
	Geodesics	64
	Examples	67
	Path integral formulation of quantum mechanics	71
	Exercises	75
CHAPTER V	INVARIANCE TRANSFORMATIONS AND CONSTANTS OF THE MOTION	80
	Invariance transformations	80
	Free particle (a)	81
	Infinitesimal transformations	82
	Free particle (b)	83
	Space time transformations	84
	Spatial displacement	85
	Spatial rotation	85
	Galilean transformation	87
	Time displacement	88
	Covariance, invariance, and the action	90
	Exercises	96
CHAPTER VI	HAMILTON'S EQUATIONS	98
	Hamilton's equations	98
	Plane pendulum	101
	Spherical pendulum	103
	Rotating pendulum	104
	Electromagnetic interaction	107
	Poisson brackets	107
	Exercises	110
CHAPTER VII	CANONICAL TRANSFORMATIONS	115
	One degree of freedom	115
	Generating functions	119

Identity and point transformations	123
Infinitesimal canonical transformations	125
Invariance transformations	126
Lagrange and Poisson brackets	128
Time dependence	132
Integral invariants	134
Exercises	140
CHAPTER VIII HAMILTON-JACOBI THEORY	143
Hamilton's principal function	143
Jacobi's complete integral	147
Time-independent Hamilton-Jacobi equation	151
Separation of variables	155
Free particle, in cartesian coordinates	155
Central force, in spherical polar coordinates	157
Hamilton-Jacobi mechanics, geometric optics, and wave mechanics	162
Exercises	167
CHAPTER IX ACTION-ANGLE VARIABLES	171
Action-angle variables	171
Example: simple harmonic oscillator	176
Example: central force	178
Adiabatic change	181
Exercises	187
CHAPTER X NON-INTEGRABLE SYSTEMS	191
Surface of section	191
Integrable and non-integrable systems	196
Perturbation theory	199
Irrational tori	201
Rational tori	203
Exercises	207
INDEX	210