

# Contents

<b>1. Introduction</b> .....	1
1.1 History .....	1
1.2 Global vs. Local Notation .....	4
1.3 Summary of Chapters .....	6
1.4 Further Reading .....	8
<b>2. Equations of Celestial Mechanics</b> .....	9
2.1 $N$ -Body Problem .....	9
2.2 The Kepler Problem .....	11
2.3 Restricted Problem .....	12
2.4 Hill's Lunar Equations .....	16
2.5 Elliptic Problem .....	17
2.6 Problems .....	17
<b>3. Hamiltonian Systems</b> .....	19
3.1 Hamiltonian Systems .....	19
3.2 Symplectic Coordinates .....	20
3.3 Generating Functions .....	22
3.4 Rotating Coordinates .....	24
3.5 Jacobi Coordinates .....	25
3.6 Action-Angle and Polar Coordinates .....	30
3.7 Solution of the Kepler Problem .....	31
3.8 Spherical Coordinates .....	34
3.9 Symplectic Scaling .....	36
3.10 Problems .....	37
<b>4. Central Configurations</b> .....	39
4.1 Equilibrium Solutions .....	39
4.2 Equations for a Central Configuration .....	39
4.3 Relative Equilibrium .....	41
4.4 Lagrangian Solutions .....	42
4.5 Euler-Moulton Solutions .....	43
4.6 Central Configuration Coordinates .....	45
4.7 Problems .....	49

<b>5. Symmetries, Integrals, and Reduction</b> .....	51
5.1 Group Actions and Symmetries .....	53
5.2 Systems with Integrals .....	60
5.3 Noether's Theorem .....	61
5.4 Integrals .....	63
5.5 Symplectic Reduction .....	64
5.6 Reducing the $N$ -Body Problem .....	66
5.7 Problems .....	70
<b>6. Theory of Periodic Solutions</b> .....	71
6.1 Equilibrium Points .....	71
6.2 Fixed Points .....	73
6.3 Periodic Differential Equations .....	75
6.4 Autonomous Systems .....	76
6.5 Systems with Integrals .....	79
6.6 Systems with Symmetries .....	83
6.7 Hamiltonian Systems with Symmetries .....	85
6.8 Problems .....	85
<b>7. Satellite Orbits</b> .....	87
7.1 Main Problem for Satellite Problem .....	87
7.2 Continuation of Solutions .....	89
7.3 Problems .....	90
<b>8. The Restricted Problem</b> .....	91
8.1 Main Problem for the Three-Bodies .....	92
8.2 Continuation of Periodic Solutions .....	96
8.3 Bifurcations of Periodic Solutions .....	98
8.4 Main Problem for $(N + 1)$ -Bodies .....	100
8.5 Reduction .....	101
8.6 Continuation of Periodic Solutions .....	102
8.7 Problems .....	102
<b>9. Lunar Orbits</b> .....	105
9.1 Main Problem .....	105
9.2 Continuation .....	107
9.3 Problems .....	110
<b>10. Comet Orbits</b> .....	111
10.1 Jacobi Coordinates and Scaling .....	111
10.2 Kepler Problem .....	112
10.3 Main Problem .....	113
10.4 Reduced Space .....	115
10.5 Continuation .....	116
10.6 Problems .....	117

**11. Hill's Lunar Equations** ..... 119

    11.1 Main Problem ..... 120

    11.2 Continuation ..... 125

    11.3 Problems ..... 126

**12. The Elliptic Problem** ..... 129

    12.1 Apollonius Coordinates ..... 130

    12.2 Relative Equilibrium ..... 132

    12.3 Main Problem ..... 133

    12.4 Symmetries and Reduction ..... 135

    12.5 Continuation ..... 136

    12.6 Problems ..... 137

**References** ..... 138

**Index** ..... 143