Contents

Spinning Bodies: A Tutorial
Tadashi Tokieda 1
1 Introduction 1
2 Inertia Matrix 3
3 Conservation Laws 6
4 Miscellaneous Examples 7
5 Euler's Equations 11
6 Spinning under No Torque: Euler's Top 12
7 Some Cases of Spinning under Torques: Lagrange's Top 16
8 Kovalevskaya's Top 19
9 Appendix 20
10 Further Reading and Acknowledgement 21
References 21

Physics Inside the Earth: Deformation and Rotation
Hilaire Legros, Marianne Greff, Tadashi Tokieda 23
1 Introduction 23
2 Terrestrial Mechanics and Survey of Some Dynamical Theories 23
2.1 Historical Review 23
2.2 Physical and Mechanical Setup 24
2.3 Classical Theories 26
3 Deformation of a Planet 29
3.1 Historical Review 30
3.2 Elasto-Gravitational Deformation of a Planet 31
3.3 Viscoelastic Deformation of a Planet 39
3.4 Perspectives 46
4 Rotation of a Deformable Stratified Planet 49
4.1 Historical Review 49
4.2 Rotation with a Fluid Core and a Solid Inner Core 50

4.3 Discussion 60
4.4 Conclusion 62
References 62

Modelling and Characterizing the Earth's Gravity Field: From Basic Principles to Current Purposes
Florent Deleflie, Pierre Exertier 67
1 Introduction 67
2 Basic Principles 68
2.1 Mass and Gravitation 68
2.2 Potential Generated by a Continuous Body 70
2.3 Potential Generated by a Continuous Body in Rotation 71
3 Coefficients Characterizing the Gravity Field 72
3.1 Legendre Polynomials 72
3.2 Spherical Harmonics 73
3.3 Development of the Gravity Field in Spherical Harmonics 73
4 Global Geodynamics 75
5 Orbital Dynamics 77
5.1 Integrate the Equations of Motion 77
5.2 Computing from Space the Coefficients of the Gravity Field . . . 79
6 Current Purposes 81
6.1 Combined Gravity Field Models 81
6.2 The New Missions GRACE and GOCE 83
6.3 Towards an Alternative to Spherical Harmonics for Short Spatial Wavelengths 84
7 Conclusion 85
References 86

Asteroids from Observations to Models
D. Hestroffer, P. Tanga 89
1 Introduction 89
2 Lightcurves 89
3 Rotation 90
4 Figures of Equilibrium 95
4.1 Hydrostatic Equilibrium 96
4.2 Elastostatic Equilibrium and Elastic-Plastic Theories 101
4.3 Binary Systems and the Density Profile 103
5 The Determination of Shape and Spin Parameters by Hubble Space Telescope 105
5.1 The FGS Interferometer 105
5.2 From Data to Modeling 107
5.3 Some Significant Examples 109
6 Conclusions 113
References 114

Modelling Collisions Between Asteroids: From Laboratory Experiments to Numerical Simulations
Patrick Michel . . . 117
1 Introduction . . . 118
2 Laboratory Experiments . . . 120
2.1 Degree of Fragmentation . . . 121
2.2 Fragment Size Distribution . . . 122
2.3 Fragment Velocity Distribution . . . 122
3 Fragmentation Phase: Theoretical Basis . . . 123
3.1 Basic Equations . . . 124
3.2 Fundamental Basis of Dynamical Fracture . . . 125
3.3 Numerically Simulating the Fragmentation Phase . . . 130
3.4 Summary of Limitations Due to Material Uncertainties . . . 131
4 Gravitational Phase: Large-Scale Simulations . . . 131
5 Current Understanding and Latest Results . . . 133
5.1 Disruption of Monolithic Family Parent Bodies . . . 134
5.2 Disruption of Pre-Shattered Parent Bodies . . . 136
6 Conclusions . . . 140
References . . . 141

Geometric Conditions for Quasi-Collisions in Öpik's Theory
Giovanni B. Valsecchi . . . 145
1 Introduction . . . 145
2 The Geometry of Planetary Close Encounters . . . 146
3 A Generalized Setup for Öpik's Theory . . . 149
3.1 From Heliocentric Elements of the Small Body to Cartesian Geocentric Position and Velocity and Back . . . 149
3.2 The Local MOID . . . 151
3.3 The Coordinates on the b-Plane . . . 153
3.4 The Encounter . . . 154
3.5 Post-Encounter Coordinates in the Post-Encounter b-Plane and the New Local MOID . . . 155
3.6 Post-Encounter Propagation . . . 156
4 Discussion . . . 157
References . . . 158

The Synchronous Rotation of the Moon
Jacques Henrard . . . 159
1 Introduction . . . 159
2 Andoyer's Variables . . . 160
3 Perturbation by Another Body . . . 161
4 Cassini's States . . . 163
5 Motion around the Cassini's States . . . 165
References . . . 167

Spin-Orbit Resonant Rotation of Mercury
Sandrine D'Hoedt, Anne Lemaitre 169
1 Introduction 169
2 Reference Frames and Variables Choice 171
3 First Model of Rotation 173
4 Development of the Gravitational Potential 174
5 Spin-Orbit Resonant Angle 175
6 Simplified Hamiltonian and Basic Frequencies 177
7 Conclusion 180
References 180

Dynamics of Planetary Rings
Bruno Sicardy 183
1 Introduction 183
2 Planetary Rings and the Roche Zone 184
3 Flattening of Rings 185
4 Stability of Flat Disks 186
5 Particle Size and Ring Thickness 190
6 Resonances in Planetary Rings 192
7 Waves as Probes of the Rings 198
8 Torque at Resonances 198
9 Concluding Remarks 200
References 200

Index 201