

# Contents

<b>1</b>	<b>Particle Dynamics, Material System Dynamics and Rigid-Body Motion About a Point</b>	<b>1</b>
1.1	Dynamics of a Particle	1
1.1.1	Newton’s Second Law of Motion	1
1.1.2	Classifying Dynamics Problems	5
1.1.3	Particle Motion Under the Action of Simple Forces	7
1.1.4	Law of Conservation of Momentum	13
1.1.5	Laws of Conservation of the Kinematic Quantities of a Particle	15
1.1.6	Particle Motion in the Central Field	31
1.2	Fundamental Laws of Dynamics of a Mechanical System	41
1.2.1	Introduction	41
1.2.2	Law of Conservation of Momentum	43
1.2.3	Law of Motion of Center of Mass	45
1.2.4	Moment of Quantity of Motion (Angular Momentum)	48
1.2.5	Kinetic Energy of a DMS and a CMS	50
1.2.6	Law of Conservation of Angular Momentum	54
1.2.7	Law of Conservation of Kinetic Energy	60
1.3	Motion About a Point	62
1.3.1	Kinetic Energy, Ellipsoid of Inertia, Angular Momentum	62
	References	67
<b>2</b>	<b>Mathematical and Physical Pendulum</b>	<b>69</b>
2.1	The Mathematical Pendulum	69
2.2	The Physical Pendulum	80
2.3	Planar Dynamics of a Triple Physical Pendulum	83
2.3.1	Equations of Motion	83
2.3.2	Numerical Simulations	90
2.3.3	Dynamic Reactions in Bearings	97
	References	106

<b>3</b>	<b>Statics and Dynamics in Generalized Coordinates</b>	107
3.1	Constraints and Generalized Coordinates	107
3.2	Variational Principles of Jourdain and Gauss	129
3.3	General Equation of Statics and Stability of Equilibrium Positions of Mechanical Systems in a Potential Force Field	140
3.4	Lagrange's Equations of the First and Second Kind	152
3.5	Properties of Lagrange's Equation	176
3.6	First Integrals of Lagrange Systems	181
3.7	Routh's Equation	188
3.8	Cyclic Coordinates	192
3.9	Kinetics of Systems of Rigid Bodies: A Three-Degree- of-Freedom Manipulator	195
3.9.1	Introduction	195
3.9.2	A Physical and Mathematical Model	195
3.9.3	Results of Numerical Simulations	201
	References	206
<b>4</b>	<b>Classic Equations of Dynamics</b>	207
4.1	Hamiltonian Mechanics	207
4.1.1	Hamilton's Equations	207
4.1.2	Jacobi–Poisson Theorem	210
4.1.3	Canonical Transformations	211
4.1.4	Non-Singular Canonical Transformations and Guiding Functions	217
4.1.5	Jacobi's Method and Hamilton–Jacobi Equations	218
4.1.6	Forms of the Hamilton–Jacobi Equations in the Case of Cyclic Coordinates and Conservative Systems	220
4.2	Solution Methods for Euler–Lagrange Equations	222
4.2.1	Introduction	222
4.2.2	Euler's Theorem and Euler–Lagrange Equations	222
4.2.3	Bogomolny Equation and Decomposition	225
4.2.4	Bäcklund Transformation	226
4.3	Whittaker's Equations	229
4.4	Voronets and Chaplygin Equations	231
4.5	Appell's Equations	239
	References	246
<b>5</b>	<b>Theory of Impact</b>	249
5.1	Basic Concepts	249
5.2	Fundamental Laws of a Theory of Impact	251
5.2.1	The Law of Conservation of Momentum During Impact	251
5.2.2	The Law of Conservation of Angular Momentum During Impact	252
5.3	Particle Impact Against an Obstacle	255
5.4	A Physical Interpretation of Impact	257

5.5	Collision of Two Balls in Translational Motion .....	258
5.6	Collision of Two Freely Moving Rigid Bodies .....	263
5.7	A Center of Percussion.....	267
	References.....	269
<b>6</b>	<b>Vibrations of Mechanical Systems .....</b>	<b>271</b>
6.1	Introduction.....	271
6.2	Motion Equation of Linear Systems with $N$ Degrees of Freedom.....	272
6.3	Classification and Properties of Linear Mechanical Forces .....	275
6.4	Small Vibrations of Linear One-Degree-of-Freedom Systems.....	282
6.5	Non-Linear Conservative 1DOF System and Dimensionless Equations.....	297
6.6	One-Degree-of-Freedom Mechanical Systems with a Piecewise Linear and Impulse Loading .....	303
	References.....	321
<b>7</b>	<b>Elements of Dynamics of Planets .....</b>	<b>323</b>
7.1	Introduction.....	323
7.2	Potential Force Fields .....	327
7.3	Dynamics of Two Particles .....	328
7.4	Kepler's First Law .....	335
	References.....	339
<b>8</b>	<b>Dynamics of Systems of Variable Mass .....</b>	<b>341</b>
8.1	Introduction.....	341
8.2	Change in Quantity of Motion and Angular Momentum.....	341
8.3	Motion of a Particle of a Variable Mass System .....	343
8.4	Motion of a Rocket (Two Problems of Tsiolkovsky).....	346
	8.4.1 First Tsiolkovsky Problem.....	346
	8.4.2 Second Tsiolkovsky Problem.....	348
8.5	Equations of Motion of a Body with Variable Mass.....	351
	References.....	357
<b>9</b>	<b>Body and Multibody Dynamics .....</b>	<b>359</b>
9.1	Rotational Motion of a Rigid Body About a Fixed Axis .....	359
9.2	Motion of a Rigid Body About a Fixed Point.....	363
9.3	Dynamics of Rigid-Body Motion About a Fixed Point in a Gravitational Field.....	372
9.4	General Free Motion of a Rigid Body.....	378
9.5	Motion of a Homogeneous Ball on a Horizontal Plane in Gravitational Field with Coulomb Friction .....	380
9.6	Motion of a Rigid Body with an Arbitrary Convex Surface on a Horizontal Plane .....	386
9.7	Equations of Vibrations of a System of $N$ Rigid Bodies Connected with Cardan Universal Joints.....	389
9.8	Conservative Vibrations of a Rigid Body Supported Elastically in the Gravitational Field .....	399

9.9	A Wobblestone Dynamics .....	412
9.9.1	Coulomb–Contensou Friction Model .....	412
9.9.2	Tangens Hyperbolicus Approximations of the Spatial Model of Friction .....	421
	References .....	432
<b>10</b>	<b>Stationary Motions of a Rigid Body and Their Stability .....</b>	<b>433</b>
10.1	Stationary Conservative Dynamics .....	433
10.2	Invariant Sets of Conservative Systems and Their Stability .....	439
	References .....	441
<b>11</b>	<b>Geometric Dynamics .....</b>	<b>443</b>
11.1	Introduction .....	443
11.2	The Jacobi Metric on $Q$ .....	449
11.3	The Jacobi–Levi-Civita Equation .....	453
11.4	The JLC Equation in Geodesic Coordinates .....	457
11.5	The JLC Equation for the Jacobi Metric .....	459
11.6	Mechanical Systems with Two Degrees of Freedom .....	460
	References .....	465



<http://www.springer.com/978-1-4614-3739-0>

Classical Mechanics

Dynamics

Awrejcewicz, J.

2012, XIV, 466 p., Hardcover

ISBN: 978-1-4614-3739-0