
Contents

	Introduction	1
1	Modeling and computer simulations	1
1.1	Modeling vs. simulation	5
1.2	Art of modeling	7
1.3	Computer in the contemporary world	11
2	Numerical solutions of equations — algebra	13
2.1	Numerical solving of nonlinear equations	13
2.1.1	Bisection method	14
2.1.2	Regula Falsi method	16
2.1.3	Newton's method	17
2.1.4	Sturm theorem	18
2.2	Definitions and examples	19
2.3	Numerical solving of systems of linear equations	26
2.3.1	Exact methods	26
2.3.2	Iterative methods	30
2.4	Eigenproblem of the matrix	34
3	Numerical solutions of equations — calculus	37
3.1	Ordinary differential equations and integrals	38
3.2	Difference methods	43
3.2.1	One-step methods	43
3.2.2	Many-steps methods	45
3.2.3	Iterative methods	47
3.2.4	Runge-Kutta methods	48
3.3	Numerical integration	49
3.3.1	Midpoint rule	50
3.3.2	Trapezoid rule	51
3.3.3	Simpson's rule	51

4	Example from physics – pendulum	53
4.1	Pendulum	57
4.1.1	Mathematical pendulum	57
4.1.2	Physical pendulum	64
4.2	Example of physical pendulum – Foucault pendulum	66
5	Cellular automata	69
5.1	Fundamentals of cellular automata	70
5.2	<i>Game of Life</i> and other configurations	72
5.3	Simulation of motion – Flock	77
5.4	Percolation	79
6	Deterministic chaos	83
6.1	Logistic iteration	83
6.2	Attractors	86
6.3	Butterfly effect	86
7	Mechanics of material points and solid bodies	91
7.1	Dynamics of material points	91
7.2	Mechanics of a solid body	97
7.3	Kinematics of a solid body	98
7.3.1	Motion	99
7.3.2	Momentum	100
7.3.3	Energy	101
7.3.4	Angular momentum	102
7.4	Friction	103
8	Modeling of planetary systems	107
8.1	Solar System	108
8.2	Overview of the planets of the Solar System	112
8.3	Ancient astronomy	117
8.4	Copernicus Solar System	119
8.5	Kepler's laws of planetary motion	120
8.6	Law of universal gravitation	123
8.7	Cosmic velocities	124
8.8	Computer simulation of the Solar System	125
9	Fabrics	129
9.1	Modeling	129
9.1.1	Physical model	129
9.1.2	Mathematical model	130
9.1.3	Numerical model	132
9.2	Computer simulations of a fabric	133

10 Markov processes	139
10.1 Markov chains and processes	140
10.2 Reminders	143
10.3 Examples of Markov processes	146
11 Fractals	151
11.1 Examples of fractals	152
11.2 Constructive fractals	153
11.2.1 Cantor set (1883)	153
11.2.2 Koch snowflake	154
11.2.3 Sierpiński carpets	155
11.3 Iterative fractals	159
11.3.1 Julia sets	159
11.3.2 The Mandelbrot set	162
11.3.3 Barnsley fern	164
11.4 Applications of fractals	166
12 Einstein's theory of relativity	169
12.1 Michelson–Morley experiment	172
12.2 Galileo transformation	176
12.3 Lorentz transformation	177
12.4 Satellite Positioning Systems	180
13 Linear programming	185
13.1 Standard form of linear programming	187
13.2 Analytical method	190
13.3 Graphical method	193
14 Genetic algorithms	195
14.1 Simple example of the genetic algorithm	198
14.2 Evolutionary strategies	200
14.3 Genetic-Based Machine Learning Systems	203
15 Dislocations in crystals	205
15.1 Kinematics of the dislocation motion	207
15.2 Computer simulations	213
15.3 Results of the computer simulation of MPE	217
16 Problems	221
List of Figures	228
References	235