

Contents

Preface to the Third Edition	v
List of Tables	xv
1 Introduction to Computer Algebra	1
1.1 What is Computer Algebra?	1
1.2 Computer Algebra Systems	2
1.3 Some Properties of Computer Algebra Systems	5
1.4 Advantages of Computer Algebra	11
1.5 Limitations of Computer Algebra	23
1.6 Design of Maple	29
2 The First Steps: Calculus on Numbers	33
2.1 Getting Started	33
2.2 Getting Help	36
2.3 Integers and Rational Numbers	41
2.4 Irrational Numbers and Floating-Point Numbers	46
2.5 Algebraic Numbers	53
2.6 Complex Numbers	58
2.7 Exercises	63
3 Variables and Names	65
3.1 Assignment and Unassignment	65
3.2 Evaluation	73

3.3	Names of Variables	77
3.4	Basic Data Types	83
3.5	Attributes	88
3.6	Properties	89
3.7	Exercises	93
4	Getting Around with Maple	95
4.1	Maple Input and Output	95
4.2	The Maple Library	101
4.3	Reading and Writing Files	106
4.4	Importing and Exporting Numerical Data	113
4.5	Low-level I/O	116
4.6	Code Generation	127
4.7	Changing Maple to Your Own Taste	133
4.8	Exercises	137
5	Polynomials and Rational Functions	139
5.1	Univariate Polynomials	139
5.2	Multivariate Polynomials	145
5.3	Rational Functions	147
5.4	Conversions	148
5.5	Exercises	151
6	Internal Data Representation and Substitution	153
6.1	Internal Representation of Polynomials	153
6.2	Generalized Rational Expressions	159
6.3	Substitution	161
6.4	Exercises	174
7	Manipulation of Polynomials and Rational Expressions	175
7.1	Expansion	175
7.2	Factorization	178
7.3	Canonical Form and Normal Form	181
7.4	Normalization	183
7.5	Collection	185
7.6	Sorting	187
7.7	Exercises	188
8	Functions	189
8.1	Mathematical Functions	189
8.2	Arrow Operators	193
8.3	Piecewise Defined Functions	195
8.4	Maple Procedures	201
8.5	Recursive Procedure Definitions	204
8.6	unapply	208

8.7	Operations on Functions	209
8.8	Anonymous Functions	210
8.9	Exercises	211
9	Differentiation	213
9.1	Symbolic Differentiation	213
9.2	Automatic Differentiation	220
9.3	Exercises	224
10	Integration and Summation	225
10.1	Indefinite Integration	225
10.2	Definite Integration	234
10.3	Numerical Integration	239
10.4	Integral Transforms	241
10.5	Assisting Maple's Integrator	250
10.6	Summation	255
10.7	Exercises	260
11	Series, Approximation, and Limits	265
11.1	Truncated Series	265
11.2	Approximation of Functions	276
11.3	Power Series	281
11.4	Limits	285
11.5	Exercises	287
12	Composite Data Types	289
12.1	Sequence	289
12.2	Set	292
12.3	List	294
12.4	Arrays	300
12.5	Table: <code>table</code>	316
12.6	Last Name Evaluation	319
12.7	Rectangular Table: <code>rtable</code>	321
12.8	Record Data Structure	325
12.9	Function Call	326
12.10	Conversion between Composite Data Types	328
12.11	Exercises	331
13	The Assume Facility	333
13.1	The Need for an Assume Facility	333
13.2	Basics of <code>assume</code>	338
13.3	An Algebra of Properties	342
13.4	Implementation of <code>assume</code>	344
13.5	Exercises	350
13.6	Hierarchy of Properties	350

14 Simplification	353
14.1 Automatic Simplification	354
14.2 expand	356
14.3 combine	364
14.4 simplify	370
14.5 convert	375
14.6 Trigonometric Simplification	379
14.7 Simplification w.r.t. Side Relations	382
14.8 Control Over Simplification	386
14.9 Defining Your Own Simplification Routines	391
14.10 Exercises	397
14.11 Simplification Chart	399
15 Graphics	401
15.1 Some Basic Two-Dimensional Plots	403
15.2 Options of plot	407
15.3 The Structure of Two-Dimensional Graphics	418
15.4 The plottools Package	422
15.5 Special Two-Dimensional Plots	426
15.6 Two-Dimensional Geometry	436
15.7 Plot Aliasing	438
15.8 A Common Mistake	439
15.9 Some Basic Three-Dimensional Plots	441
15.10 Options of plot3d	442
15.11 The Structure of Three-Dimensional Graphics	448
15.12 Special Three-Dimensional Plots	452
15.13 Data Plotting	459
15.14 Animation	469
15.15 List of Plot Options	472
15.16 Exercises	477
16 Solving Equations	481
16.1 Equations in One Unknown	481
16.2 Abbreviations in solve	483
16.3 Some Difficulties	485
16.4 Systems of Equations	492
16.5 The Gröbner Basis Method	501
16.6 Inequalities	508
16.7 Numerical Solvers	510
16.8 Other Solvers in Maple	512
16.9 Exercises	519
17 Differential Equations	521
17.1 First Glance at ODEs	522
17.2 Analytic Solutions	524

17.3	Lie Point Symmetries for ODEs	538
17.4	Taylor Series Method	560
17.5	Power Series Method	561
17.6	Numerical Solutions	566
17.7	Graphical Methods	580
17.8	Change of Coordinates	586
17.9	Perturbation Methods	590
17.10	Partial Differential Equations	600
17.11	Lie Point Symmetries of PDEs	615
17.12	Exercises	617
18	The LinearAlgebra Package	619
18.1	Loading the LinearAlgebra Package	619
18.2	Creating Vectors and Matrices	621
18.3	Vector and Matrix Arithmetic	629
18.4	Basic Matrix Functions	634
18.5	Structural Operations	641
18.6	Vector Operations	645
18.7	Standard Forms of Matrices	646
18.8	Numeric Linear Algebra	656
18.9	Exercises	660
19	Linear Algebra: Applications	663
19.1	Kinematics of the Stanford Manipulator	663
19.2	A 3-Compartment Model of Cadmium Transfer	669
19.3	Molecular-Orbital Hückel Theory	680
19.4	Vector Calculus	687
19.5	Moore-Penrose Inverse	693
19.6	Exercises	694
20	A Bird's-Eye View of Gröbner Bases	697
20.1	Introduction	697
20.2	Elementary Solution Methods	702
	20.2.1 Heuristic Method	702
	20.2.2 Gaussian Elimination-Like Method	702
	20.2.3 Conclusion	703
20.3	Basics of the Gröbner Basis Method	703
	20.3.1 Term Ordering	704
	20.3.2 Polynomial Reduction and Normal Form	710
	20.3.3 Characterization of a Gröbner Basis	712
	20.3.4 The Buchberger Algorithm	714
	20.3.5 Improvements of Buchberger's Algorithm	716
20.4	Properties and Applications of Gröbner Bases	719
	20.4.1 Equivalence of Systems of Polynomial Equations	720
	20.4.2 Dimension, Hilbert Series and Hilbert Polynomial	721

20.4.3	Solvability of Polynomial Equations	725
20.4.4	Finite Solvability of Polynomial Equations	729
20.4.5	Counting of Finite Solutions	730
20.4.6	Converting a System of Polynomial Equations into Triangular Form	732
20.4.7	Finding a Univariate Polynomial	734
20.4.8	Decomposition of Ideals	735
20.4.9	An Example From Robotics	739
20.4.10	Implicitization of Parametric Objects	740
20.4.11	Invertibility of Polynomial Mappings	742
20.4.12	Simplification of Expressions	742
20.4.13	Working over General Algebras	743
20.5	Exercises	745
	References	747
	Index	761

List of Tables

1.1	Components of the Maple system.	30
2.1	The on-line Maple help system.	40
2.2	Mathematical constants in Maple.	48
2.3	Commonly used mathematical functions known to Maple.	50
2.4	Selectors on RootOf	57
3.1	Utility functions for usage of names.	69
3.2	Evaluation for assignment and unassignment.	72
3.3	Reserved words in Maple.	78
3.4	Quotation marks and percentage symbols.	83
3.5	Commonly used surface data types	84
3.6	Tests for types.	86
3.7	Combinations of colon, semicolon, and equal sign.	87
4.1	userinfo -facility.	98
4.2	Subpackages of stats package.	104
4.3	Reading and writing of Maple files.	112
4.4	Maple streams: opening, and closing.	117
4.5	Low-level formatted I/O routines.	119
4.6	Flags in printf	120
4.7	Conversion codes in printf	121
4.8	Character escape codes.	122
4.9	Conversion codes in fscanf , scanf , and sscanf	123

4.10	Values of <code>errorbreak</code>	136
10.1	Some elliptic integrals in Maple.	238
10.2	Integral transforms in Maple	241
12.1	Selection in sequence, set, or list.	300
12.2	Built-in special indexing functions.	310
12.3	Formats of call of special indexing function.	311
12.4	Comparison of arrays, matrices, <code>Arrays</code> , and <code>Matrices</code> . . .	315
12.5	Main conversions from composite data type S to T	331
13.1	Commands of assume facility	338
15.1	<code>Plottools</code> functions to alter graphics objects.	424
15.2	List plotting.	459
15.3	Dutch consumption of beverages per inhabitant.	459
15.4	Statistical plotting commands in <code>statplots</code> subpackage. .	465
16.1	Options of <code>fsolve</code>	510
17.1	Some solvable first order ODEs.	532
17.2	Some solvable second order ODEs.	533
17.3	Options of <code>dsolve(ODE, type=exact)</code>	538
17.4	Lie's classification of second-order ODEs that admit a 2- dimensional symmetry algebra.	558
17.5	Main commands in <code>DEtools</code> package for Lie symmetry approach.	560
17.6	Numerical methods provided by <code>dsolve</code> for initial value problems.	577
17.7	Numerical methods provided by <code>dsolve</code> for boundary value problems.	577
17.8	Lie Point Symmetries of KdV-Equation.	617
18.1	Options of <code>Vector</code> and <code>Matrix</code>	621
18.2	Procedures related to special vectors and matrices.	624
18.3	Basic functions in the <code>LinearAlgebra</code> package.	641
18.4	Structural operators.	641
18.5	Test functions for matrices.	642
18.6	Vector operations.	645
18.7	Test functions for matrices.	646
19.1	Some predefined 2D orthogonal curvilinear coordinates. .	688
19.2	Some predefined 3D orthogonal curvilinear coordinates. .	689