

Contents

I	Analysis of differential-algebraic equations	1
1	Introduction	3
1.1	Solvability concepts	5
1.2	Index concepts	6
1.3	Applications	8
1.4	How to use this book in teaching	11
2	Linear differential-algebraic equations with constant coefficients	13
2.1	Canonical forms	13
2.2	The Drazin inverse	22
2.3	Explicit representation of solutions	27
2.4	Generalized solutions	32
2.5	Control problems	48
	Bibliographical remarks	52
	Exercises	53
3	Linear differential-algebraic equations with variable coefficients	56
3.1	Canonical forms	56
3.2	Local and global invariants	80
3.3	The differentiation index	96
3.4	Differential-algebraic operators and generalized inverses	114
3.5	Generalized solutions	132
3.6	Control problems	138
	Bibliographical remarks	147
	Exercises	147
4	Nonlinear differential-algebraic equations	151
4.1	Existence and uniqueness of solutions	151
4.2	Structured problems	167
4.3	Over- and underdetermined problems	182
4.4	Control problems	189
4.5	Differential equations on manifolds	195
	Bibliographical remarks	210
	Exercises	210

II Numerical solution of differential-algebraic equations	215
5 Numerical methods for strangeness-free problems	217
5.1 Preparations	218
5.2 One-step methods	224
5.3 Multi-step methods	254
Bibliographical remarks	270
Exercises	270
6 Numerical methods for index reduction	273
6.1 Index reduction for linear problems	274
6.2 Index reduction for nonlinear problems	279
6.3 Index reduction via feedback control	284
6.4 Index reduction by minimal extension	286
Bibliographical remarks	295
Exercises	295
7 Boundary value problems	298
7.1 Existence and uniqueness of solutions	299
7.2 Multiple shooting	304
7.3 Collocation	314
Bibliographical remarks	348
Exercises	348
8 Software for the numerical solution of differential-algebraic equations	352
Bibliographical remarks	355
Exercises	355
Final remarks	357
Bibliography	359
Index	373