

Studies in Logic

Mathematical Logic and Foundations

Volume 40

The Lambda Calculus,
its Syntax and Semantics

CONTENTS

PREFACE	vii	5.4. Models in concrete cartesian closed categories	104
HINTS FOR THE READER	xiii	5.5. Models in cartesian closed categories	107
PART I. TOWARDS THE THEORY	1	5.6. Other model descriptions; categorical models	116
1. Introduction	3	5.7. Survey of part V	122
1.1. Aspects of the lambda calculus	3	5.8. Exercises	127
1.2. Complete partial orders and the Scott topology	9	PART II. CONVERSION	129
1.3. Exercises	19	6. Classical Lambda Calculus	131
2. Conversion	22	6.1. Fixed point combinators	131
2.1. Lambda terms and conversion	22	6.2. Standard combinators	132
2.2. Some variants of the theory	35	6.3. Lambda definability	135
2.3. Survey of part II	43	6.4. Numeral systems	139
2.4. Exercises	49	6.5. More about fixed points; Gödel numbers	141
3. Reduction	50	6.6. Undecidability results	144
3.1. Notions of reduction	50	6.7. Self-referential sentences and the recursion theorem	146
3.2. Beta reduction	59	6.8. Exercises	148
3.3. Eta reduction	63	7. The Theory of Combinators	151
3.4. Survey of part III	67	7.1. Combinatory logic	151
3.5. Exercises	73	7.2. Reduction for <i>CL</i>	154
4. Theories	76	7.3. The relation between <i>CL</i> and λ	156
4.1. Lambda theories	76	7.4. Exercises	163
4.2. Survey of part IV	83	8. Classical Lambda Calculus (Continued)	165
4.3. Exercises	85	8.1. Bases and enumeration	165
5. Models	86	8.2. Uniformity; infinite sequences	168
5.1. Combinatory algebras	86	8.3. Solvability; head normal forms	171
5.2. Lambda algebras and models	91	8.4. Definability of partial functions	178
5.3. Syntactical models	101	8.5. Exercises	183

9. The λI -Calculus	185	15. Other Notions of Reduction	384
9.1. Generalities	185	15.1. BH -reduction	384
9.2. Definability	187	15.2. $BH\Omega$ -reduction	388
9.3. Combinators	192	15.3. Delta reduction	400
9.4. Solvability	199	15.4. Exercises	407
9.5. Exercises	213		
10. Böhm Trees	215	PART IV. THEORIES	409
10.1. Basics	215	16. Sensible Theories	411
10.2. Comparing Böhm trees; the tree topology on Λ	229	16.1. The theory \mathcal{K}	411
10.3. The Böhm out technique	245	16.2. The theory \mathcal{K}^*	416
10.4. Separability of terms	254	16.3. 2^{\aleph_0} sensible theories	421
10.5. Separability in the λI -calculus	260	16.4. The theory \mathfrak{B}	425
10.6. Exercises	270	16.5. Exercises	429
PART III. REDUCTION	273	17. Other Lambda Theories	431
11. Fundamental Theorems	277	17.1. Semi-sensible and r.e. theories	431
11.1. The Church–Rosser theorem	277	17.2. Omega theories	437
11.2. The finiteness of developments	283	17.3. Partial validity of the ω -rule $\lambda\eta$	445
11.3. The conservation theorem for λI	293	17.4. The ω -rule and $\mathcal{K}\eta$	457
11.4. Standardization	296	17.5. Exercises	465
11.5. Exercises	301		
12. Strongly Equivalent Reductions	302	PART V. MODELS	467
12.1. Reduction diagrams	302	18. Construction of Models	469
12.2. Strong versions of CR and FD!	311	18.1. The graph model $P\omega$	469
12.3. Strong version of standardization	317	18.2. The models D_∞	477
12.4. Exercises	323	18.3. The model \mathfrak{B}	486
13. Reduction Strategies	324	18.4. Exercises	491
13.1. Classification of strategies	324	19. Local Structure of Models	496
13.2. Effective normalizing and cofinal strategies	326	19.1. Local structure of $P\omega$	496
13.3. A recursive CR strategy	333	19.2. Local structure of D_∞	504
13.4. An effective perpetual strategy	338	19.3. Continuous λ -models	508
13.5. Optimal strategies	344	19.4. Exercises	511
13.6. Exercises	349	20. Global Structure of Models	513
14. Labelled Reduction	352	20.1. Extensionality; categoricity	513
14.1. Strong normalization	352	20.2. The range property	516
14.2. Applications	359	20.3. Nondefinability results	519
14.3. Continuity	364	20.4. Local vs. global representability	520
14.4. Sequentiality and stability	375	20.5. The tree topology on models	525
14.5. Exercises	382	20.6. Exercises	529

21. Combinatory Groups	532	Appendix C. Variables	577
21.1. Combinatory semigroups	532	Final exercises	581
21.2. Characterization of invertibility	535		
21.3. The groups $G(\lambda\eta)$ and $G(\mathcal{K}^*)$	547	Addenda	582
21.4. Exercises	554		
APPENDICES	557	References	585
Appendix A. Typed Lambda Calculus	561	Index of Names	599
A.1. The pure typed lambda calculus	561	Index of Definitions	605
A.2. Primitive recursive functionals	568		
A.3. Formulae as types	572	Index of Symbols	611
Appendix B. Illative Combinatory Logic	573	ERRATA	E 1