

Contents

Preface	v
---------------	---

Chapter 1. The Abstract Rational Outlook	1
---	---

Abstract Computation.....	2
Rational Thought.....	4
Human Psychology	6
Mythological Language	8
Literate Programming.....	10
Hand-Crafted Software	12
Technical Programming.....	14

Chapter 2. A Grab Bag of Computational Models	17
--	----

Abstract and Virtual Machines	18
State Machines	20
State Machines in Action	22
Turing Machine	26
Non-Deterministic Machines	30
Von Neumann Machine.....	34
Stack Machine.....	36
Register Machine	38
Analogue Machine.....	39
Cellular Automata.....	40
Unorthodox Models	41
The Game of Life.....	42
The Modern Desktop Computer	44
Aspects of Virtual Machines	46
Aspects of Programming.....	48
Register Indirection	50
Pure Expression Substitution	52
Lists Pure and Linked	54
Pure String Substitution.....	56
The Face Value of Numerals	58
Solving Equations	62
Pure Unification	64
Equality of Expressions.....	66
Equational Reasoning	68

Unification Reduction	70
Code Reduction	74
Programming With Logic.....	76
Negation in Logic Programming	78
Impure Lambda Calculus.....	80
Pure Lambda Calculus	82
Pure Lambda Arithmetic	84
Pure Lambda Flow Control.....	86
S-K Combinators	90
 Chapter 3. Some Formal Technology	92
The Ellipsis Is Not a Definition	93
The Summation Operator	95
Propositional Calculus.....	97
Boolean Algebra.....	99
Predicate Calculus	101
Formal Mathematical Models.....	102
The Formal State Machine	103
Several Types of Networks.....	105
Informal Petri Nets.....	107
Formal Turing Machine.....	109
The Table-Driven State Machine	110
Factors of Graphs	111
Products of Graphs.....	113
Constructive Numerics	115
Prime Programs.....	117
Showing that Factorial Works	119
Reasoning About Code.....	123
Logical Conditions	127
 Chapter 4. Limitations on Exact Knowledge	131
Finite-State Limitations	132
N log N sorting.....	133
Russell's Paradox.....	134
Pure Lambda Paradoxes.....	136
Godel's Theorem	138
Non-Computability	140
Solving Polynomials	142

Churche's Thesis	143
Algorithmic Complexity	144
P and NP	146
NP completeness	148
Turing Test	149
Natural Language Processing	150
The Computable Reals	151
The Diagonal Argument	152
Chapter 5. Some Orthodox Languages.....	154
C Pointers to Functions	159
Taking C on Face Value	161
Functions and Other Data in C.....	163
The C Preprocessor	166
C Functions are Data Again	167
Java Code.....	169
Pointer Casting	171
The Object Data Type	177
Manual Objects	179
Inheritance and Dynamic Type.....	181
CODASYL and Objects	183
Typecasting	185
The Concept of Type.....	187
Type-Checking	188
Subtypes and Programming	189
New Datatypes.....	190
Scheme Code.....	193
Declarative and Imperative	195
Sorting with Pure Substitution	197
Fast Sorting in Haskell	199
Logic in Prolog.....	201
Functions in Prolog.....	204
Arithmetic in Prolog	205
Meta-Logic in Prolog.....	207
What Is HTML Code?	209
Illogical markup language	211
HTML Forgive and Forget.....	212
Expanding Beyond Recognition	213

Chapter 6. Arithmetic Computation	214
Natural Arithmetic	215
Modulo Arithmetic	217
Integer Arithmetic	219
Rational Arithmetic	221
Complex Arithmetic	223
Exact Arithmetic	225
Showing That a Power Loop Works	227
When Is a Proof Not a Proof?	229
Real-Valued Memory	231
Cellular Matrix Multiplication	232
Chapter 7. Repetitive Computation	235
The Use of Recursion	236
Doing Without the While Loop	238
Defining the Generic While-Loop	240
Design of the Power Function	244
Powers by Multiplication	246
Computing Powers by Squaring	248
Language or Algorithm?	250
Repetitive Program Design	253
Recursive Code Compilation	254
Functions as Data	256
Lambda Expressions in Java	258
The <i>Y</i> -combinator definition	260
<i>Y</i> -combinator factorial	263
<i>Y</i> -combinator Fibonacci	264
Chapter 8. Temporal Interaction	265
Virtual Interaction	266
Incorruptible Operations	268
Temporal Computing	270
Multi-Threaded Code	272
Graphs of State Machines	273
Direct Thread Composition	274
Concurrent Thread Interference	276
Control Structures	278

Thread Point of Execution	280
The Transition Network	281
High-Level Interference	285
Incorruptible Commands Again.....	286
Thread Interaction	288
Pure String Interaction	292
Showing That a Parser Works.....	295
Mutual Exclusion	296
Good Mutual Exclusion	298
A Partial Mutex Protocol	299
Guarded Commands.....	300
Blocking Commands.....	306
Hardware Assistance	307
Proving That a Protocol Works.....	308
Two Partial Exclusion Protocols.....	309
The Peterson Protocol.....	310
The Decker Protocol	312
Proving That a Protocol Works.....	314
Chapter 9. Container Datatypes	315
Abstract Arrays	316
Pure Containers	318
Generic Maps	322
Showing That Infinite Lists Work.....	325
Generic Lists	326
Computing with Infinite Lists	328
Sequence Builder	330
Infinite Lists in Haskell	333
Infinite Lists in Scheme.....	334
Primitive List Recursion.....	336
Appendices	339
End notes	340
Bibliography	351
Glossary	353
Index	355