## Contents

ה ה	r .
Urai	000
110	AUE
	ave

	٠	٠	
37			
- 3			
			٠

1 LOGIC AND EQUATIONS
-----------------------

1	Con	nputer Systems: Simple Principles Lead to Complex Behavior	3
	1.1	Hardware and Software	3
	1.2	Structure of a Program	5
	1.3	Deep Blue and Inductive Definitions	9
		Exercises	12
2	Boo	lean Formulas and Equations	15
	2.1	Reasoning with Equations	15
		Exercises	18
	2.2	Boolean Equations	19
		Exercises	26
	2.3	Boolean Formulas	27
		Exercises	32
	2.4	Digital Circuits	33
		Exercises	36
	2.5	Deduction	37
		Exercises	49
	2.6	Predicates and Quantifiers	51
		Exercises	54
	2.7	Reasoning with Quantified Predicates	55
		Exercises	62
	2.8	Boolean Models	63
		Exercises	68

	2.9	More General Models with Predicates and Quantifiers	68
3	Softv	vare Testing and Prefix Notation	71
-		Exercises	76
4	Matl	nematical Induction	79
•	4 1	Lists as Mathematical Objects	79
		Exercises	84
	4.2	Mathematical Induction	85
		Exercises	91
	4.3	Defun: Defining Operators in ACL2	92
	4.4	Concatenation, Prefixes, and Suffixes	93
		Exercises	99
5	Mec	hanized Logic	101
	5.1	ACL2 Theorems and Proofs	102
	5.2	Using Books of Proven Theorems	103
		Exercises	104
	5.3	Theorems with Constraints	105
		Exercises	107
	5.4	Helping Mechanized Logic Find Its Way	107
		Exercises	111
	5.5	Proof Automation and Things That Can't Be Done	112
		Exercises	119
II	CO	MPUTER ARITHMETIC	
6	Bin	ary Numerals	123
	6.1	Numbers and Numerals	123
		Exercises	125
	6.2	Numbers from Numerals	120
		Exercises	133
	6.3	Binary Numerals	133
		Exercises	135
7	Ad	ders	139
	7.1	Adding Numerals	120
		Exercises	140
	7.2	Circuits for Adding One-Bit Binary Numerals	140
		-	110

## Contents

	7.3	Circuit for Adding Two-Bit Binary Numerals	143
		Exercises	145
	7.4	Adding w-Bit Binary Numerals	145
		Exercises	148
	7.5	Numerals for Negative Numbers	150
		Exercises	153
8	Mul	tipliers and Bignum Arithmetic	157
	8.1	Bignum Adder	158
		Exercises	161
	8.2	Shift-and-Add Multiplier	161
		Exercises	165
III	ALC	GORITHMS	
9	Mul	tiplexers and Demultiplexers	169
	9.1	Multiplexer	169
		Exercises	172
	9.2	Demultiplexer	173
		Exercises	175
10	Sort	ting	177
	10.1	Insertion-Sort	178
		Exercises	180

10.2 Order-Preserving Merge

10.4 Analysis of Sorting Algorithms

10.4.1 Counting Computation Steps

10.4.3 Computation Steps in Merge

10.4.2 Computation Steps in Demultiplex

10.4.4 Computation Steps in Merge-Sort

10.4.5 Computation Steps in Insertion-Sort

Exercises

Exercises

Exercises

Exercises

Exercises

Exercises

10.3 Merge-Sort

•	v
_ 1	Λ.

	Exercises
11	Search Trees
	11.1 Finding Things
	11.2 The AVL Solution
	11.3 Representing Search Trees
	11.4 Ordered Scarch Trees
	Exercises
	11.5 Balanced Search Trees
	Exercises
	11.6 Inserting a New Item in a Search Tree
	Exercises
	11.7 Insertion, Case by Case
	Exercises
	11.8 Double Rotations
	Exercises
	11.9 Fast Insertion
	Exercises
12	Hash Tables

Hash Tables	
12.1 Lists and Arrays	227
12.2 Hash Operators	229
Exercises	234
12.3 Some Applications	236

## IV COMPUTATION IN PRACTICE

Sharding with Facebook	243
13.1 The Technical Challenge	243
13.2 Stopgap Remedies	245
13.2.1 Caching	245
13.2.2 Sharding	246
13.3 The Cassandra Solution	247
13.4 Summary	249
Parallel Computation with MapReduce	251
14.1 Vertical and Horizontal Scaling	251
14.2 The MapReduce Strategy	252
14.3 Data Mining with MapReduce	256
	<ul> <li>Sharding with Facebook</li> <li>13.1 The Technical Challenge</li> <li>13.2 Stopgap Remedies <ul> <li>13.2.1 Caching</li> <li>13.2.2 Sharding</li> </ul> </li> <li>13.3 The Cassandra Solution</li> <li>13.4 Summary</li> </ul> <li>Parallel Computation with MapReduce <ul> <li>14.1 Vertical and Horizontal Scaling</li> <li>14.2 The MapReduce Strategy</li> <li>14.3 Data Mining with MapReduce</li> </ul></li>

	14.4 Summary	261
15	Generating Art with Computers	263
	15.1 Representing Images in a Computer	263
	15.2 Generating Images Randomly	266
	15.3 Generating Purposeful Images	270
	Index	273