

# Contents

UNIVERSIDAD NACIONAL DE EN  
FACULTAD DE INGE  
CENTRO DE MEDI  
BIBLIOTEC

Nº 2 807

<b>Preface</b>	v
<b>Chapter 1 Introduction</b>	1
1.1 Make specifications, not programs	1
1.2 Symbolic processing language	2
1.3 Fifth generation computer systems	3
1.4 History of logic programming	4
1.4.1 Aristotelian logic	4
1.4.2 Symbolic logic	5
1.4.3 Logic programming	7
1.5 Artificial intelligence	8
1.5.1 The limits of mind	9
1.5.2 Knowledge-based systems	9
1.5.3 Expert systems	10
1.5.4 Knowledge engineering	11
<b>Chapter 2 Introduction to Logic</b>	12
2.1 Elements of logic	12
2.2 Propositional calculus	13
2.2.1 The elimination rule	15
2.2.2 Clausal form	16
2.2.3 Refutation proofs	17
2.3 First order predicate logic	20
2.3.1 Predicates and arguments	21
2.3.2 Quantifier-free notation	22
2.3.3 Formalizing queries and contradictions	22
2.3.4 Horn clause resolution	23
2.3.5 Alternative proof strategies	24
2.3.6 Functions in predicate logic	25
2.3.7 Unification of functional terms	26
2.3.8 Logic programming	26
<b>Chapter 3 Resolution</b>	29
3.1 Some logical concepts	29
3.2 Quantifiers	31
3.2.1 Examples of quantifiers	32
3.2.2 Second order logic concepts	32
3.3 First order predicate calculus	33
3.3.1 Skolem functions	34

3.3.2	From predicate logic to clausal form	35
3.3.3	Clause normalization algorithm	36
3.3.4	The complete unification algorithm	38
3.4	The resolution proof method	39
3.4.1	Resolution step	39
3.4.2	Resolution proof	40
3.4.3	Resolution proof search strategies	41
<b>Chapter 4</b>	<b>Predicate Logic as a Programming Language</b>	<b>44</b>
4.1	Syntax	44
4.1.1	Basic syntax	44
4.1.2	Functions	45
4.1.3	Clause syntax	45
4.1.4	Program structure	45
4.1.5	Describing predicates	46
4.1.6	Input/output and comments	46
4.2	The semantics of Prolog	46
4.3	Search tree	48
4.4	Recursion	48
4.5	On variable bindings	50
4.5.1	Anonymous variables	51
4.5.2	Renaming variables	51
4.5.3	Occur check	52
4.6	Symmetry properties	53
4.6.1	Symmetry of sequence of conclusions	53
4.6.2	Symmetry of sequence of conditions	53
4.6.3	Test-or-generate symmetry	54
4.6.4	Input/output parameter symmetry	54
4.7	Cutting the search tree	54
4.8	Using the cut operator, !	56
4.8.1	Negation as failure	56
4.8.2	Cut unnecessary search	58
4.8.3	Cut destroys symmetry	58
4.8.4	Variable conditions	59
4.8.5	Equality and inequality	60
<b>Chapter 5</b>	<b>Programming in Prolog</b>	<b>62</b>
5.1	Predicate library	62
5.2	Interactive Prolog	63
5.3	Basic input and output	65
5.4	Built-in operators in Prolog	66
5.5	Evaluation of expressions	67
5.6	Query processing	68
5.7	Manipulating the database	69
5.7.1	Assert	69
5.7.2	Retract	70
5.8	Operator declarations	71

5.8.1	Extralogical features	75
-------	-----------------------	----

<b>Chapter 6</b>	<b>List Processing</b>	<b>78</b>
6.1	List processing	78
6.2	S-expression	78
6.3	The empty node	79
6.4	List notation	80
6.4.1	Transforming list notation to dot notation	82
6.4.2	Transforming dot notation to list notation	83
6.4.3	Extension to Prolog S-expression	83
6.5	Elementary list predicates	84
6.5.1	The cons predicate	84
6.5.2	The member predicate	85
6.5.3	The append predicate	86
6.5.4	The delete predicate	87
6.5.5	Naive reverse	88
6.5.6	Smart reverse	88
6.6	Lists and sets	89
6.6.1	Representing information as lists or as facts	91
6.6.2	The unexpected nature of the built-in setof	92
6.6.3	Set construction without databases	94
6.7	D-lists	95
6.7.1	D-list manipulation	96
6.7.2	Limitations of Prolog list structures	97
6.8	An application: sorting	97
6.8.1	Mergesort	97
6.8.2	Quicksort	98
6.9	Alternative list syntax	99
6.9.1	Strings	99
6.9.2	Round lists	100
6.9.3	List processing with round lists	101
<b>Chapter 7</b>	<b>Logic Programming Techniques</b>	<b>104</b>
7.1	Constructing recursive programs	105
7.1.1	A closer look at recursion	105
7.1.2	Path problems	106
7.1.3	Finding the path	107
7.2	Constructing iterative programs	108
7.3	Possible implications	112
7.3.1	An application: Mastermind	112
7.4	The cut operator considered harmful	114
7.4.1	Examples of hazardous cuts	115
7.4.2	Structured use of cut	115
7.5	Resolution preprocessing	116
7.6	Inversion	117
7.7	Non-Horn logic programming	119
7.8	Meta-programming	121

7.8.1	Element by element application	122
7.8.2	Aggregate functions	123
7.9	Meta-logic	124
7.9.1	Explaining facility in meta-level logic	126
<b>Chapter 8</b>	<b>Formula Manipulation</b>	<b>130</b>
8.1	Symbolic differentiation	130
8.2	Manipulation	131
8.3	Anatomy of operator expressions	131
8.4	Formula evaluation	133
8.5	Algebraic simplification	135
8.5.1	Common subexpressions	137
8.6	Integration	138
8.7	Program verification	139
8.7.1	Program verification in Prolog	141
8.7.2	A verification condition generator	141
<b>Chapter 9</b>	<b>Logic and Databases</b>	<b>146</b>
9.1	Relational databases	146
9.1.1	A relational example	147
9.1.2	Binary relations	148
9.1.3	Composite keys	148
9.2	Database retrieval	149
9.2.1	Efficient retrieval	149
9.2.2	Virtual tables	150
9.2.3	Symbolic naming	151
9.3	Database updating	153
9.4	Data modelling	154
9.4.1	Normal forms	155
9.4.2	Relational normal forms	155
9.5	Beyond the relational model	158
9.6	Semantic nets	158
9.6.1	The class concept	159
9.7	The course model	163
9.7.1	Coupling semantic nets to tables	164
9.7.2	Typical questions	165
<b>Chapter 10</b>	<b>Logic Programming and Compiler Writing</b>	<b>167</b>
10.1	Language processing	167
10.2	Lexical analysis	167
10.3	Syntax analysis	170
10.3.1	Clause grammar	173
10.3.2	Table-driven parsing	175
10.3.3	Constructing a syntax tree	177
10.3.4	Prettyprinting a syntax tree	177
10.4	Semantics and production	178

10.5	Advanced grammar formalisms	182
10.5.1	Two-level grammars	182
10.5.2	Attribute grammars	183
<b>Chapter 11</b>	<b>Natural Language Processing</b>	<b>188</b>
11.1	What is natural language?	188
11.2	Applied natural language	188
11.3	Natural language systems in Prolog	189
11.3.1	Definite clause grammars	190
11.3.2	Natural language is ambiguous	190
11.4	Soft Systems	194
11.4.1	The Soft Systems language	194
11.4.2	Sample questions	196
11.4.3	The dialogue context	196
11.4.4	The reference model	197
11.4.5	Lexical analysis	198
11.4.6	Syntax analysis	200
11.4.7	A short attribute grammar for de-verbed language	200
11.4.8	Semantic analysis with semantic nets	202
11.4.9	Query processing	203
11.5	Pure natural language	204
11.5.1	A logic for commonsense knowledge	204
11.5.2	Why do we do what we do?	205
11.5.3	A Prolog program for a room situation	206
11.6	Natural language processing in the future	207
<b>Chapter 12</b>	<b>Logic for Problem Solving</b>	<b>209</b>
12.1	What is the problem?	209
12.2	Generalized function application	209
12.3	Algorithmic versus search problems	210
12.4	Knowledge for problem solving	211
12.4.1	Generate-and-test	213
12.4.2	Generate-or-test	214
12.5	A meta-problem solver	216
12.6	Robot planning	218
12.6.1	Kowalski's formulation	218
12.6.2	Linear planning	222
12.7	Using estimates to guide searches	222
12.7.1	Stepwise increasing length of solution	223
12.7.2	Finding short paths	224
12.7.3	Making a plan before execution	226
<b>Chapter 13</b>	<b>Expert Systems</b>	<b>229</b>
13.1	Expert systems	229
13.2	Expert systems in Prolog	230

13.3	Principles of the EXPLAIN expert system shell	231
13.3.1	Why and how – explanation	231
13.4	An example of use of EXPLAIN: television repair	232
13.5	The structure of EXPLAIN	235
13.5.1	Important predicates	235
13.5.2	EXPLAIN program skeleton	236
13.5.3	Handling of negation	237
13.5.4	Opening the closed world	237
13.5.5	Storage versus recomputation	238
13.6	EXPLAIN reference manual	239
13.6.1	Rules	239
13.6.2	Base variables and equality	240
13.6.3	Coupling to relational tables	241
13.7	EXPLAIN user guide	242
13.7.1	Expert system components	242
13.7.2	Calling EXPLAIN	243
13.7.3	Summary of commands	243
13.7.4	The EXPLAIN dialogue explained	244
13.8	Another example of EXPLAIN: pollution detection	245
13.8.1	The pollution detection knowledge base	245
13.8.2	Sample dialogue	248
13.8.3	The structure of the pollution knowledge base	249
13.9	EXPLAIN expert system shell listing	250
13.10	Non-exact reasoning	254
13.10.1	Multivalued logic	254
13.10.2	Uncertain logic	255
13.10.3	Uncertainties in EXPLAIN	257
<b>Chapter 14</b>	<b>Knowledge Engineering</b>	<b>261</b>
14.1	A knowledge engineering example	261
14.1.1	The problem	263
14.1.2	The project	263
14.1.3	Knowledge acquisition	264
14.1.4	Knowledge base statistics	265
14.1.5	Performance	266
14.1.6	User reactions	266
14.1.7	Sample dialogue for a welding consultation	267
14.2	Comparison with traditional system development	268
<b>Appendix</b>	<b>Predicate Library</b>	<b>269</b>
	<b>Bibliography</b>	<b>274</b>
	<b>Index</b>	<b>279</b>