**draft proposed American National Standard for Information Systems—Programming**

**Language—Common Lisp**

**X3J13/94-101R**

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Chapter 3 (Evaluation and Compilation)

3.1 Evaluation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–1 3.1.1 Introduction to Environments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–1 3.1.1.1 The Global Environment . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–1 3.1.1.2 Dynamic Environments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–1 3.1.1.3 Lexical Environments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–2 3.1.1.3.1 The Null Lexical Environment . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–2 3.1.1.4 Environment Objects . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–3 3.1.2 The Evaluation Model . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–3 3.1.2.1 Form Evaluation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–3 3.1.2.1.1 Symbols as Forms . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–3 3.1.2.1.1.1 Lexical Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–4 3.1.2.1.1.2 Dynamic Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–4 3.1.2.1.1.3 Constant Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–5

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Evaluation and Compilation Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3–55

Chapter 4 (Types and Classes)

4.1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–1 4.2 Types . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–2 4.2.1 Data Type Definition . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–2 4.2.2 Type Relationships . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–2 4.2.3 Type Specifiers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–3

4.3 Classes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–8 4.3.1 Introduction to Classes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–8 4.3.1.1 Standard Metaclasses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–9 4.3.2 Defining Classes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–9 4.3.3 Creating Instances of Classes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–10 4.3.4 Inheritance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–11 4.3.4.1 Examples of Inheritance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–11 4.3.4.2 Inheritance of Class Options . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–11 4.3.5 Determining the Class Precedence List . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–11 4.3.5.1 Topological Sorting . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–12 4.3.5.2 Examples of Class Precedence List Determination . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–13 4.3.6 Redefining Classes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–14 4.3.6.1 Modifying the Structure of Instances . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–15 4.3.6.2 Initializing Newly Added Local Slots . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–15 4.3.6.3 Customizing Class Redefinition . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–16 4.3.7 Integrating Types and Classes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–16 4.4 Types and Classes Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4–19

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5.1 Generalized Reference . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–1 5.1.1 Overview of Places and Generalized Reference . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–1 5.1.1.1 Evaluation of Subforms to Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–1 5.1.1.1.1Examples of Evaluation of Subforms to Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–2 5.1.1.2 Setf Expansions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–3 5.1.1.2.1 Examples of Setf Expansions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–4 5.1.2 Kinds of Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–5 5.1.2.1 Variable Names as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–5 5.1.2.2 Function Call Forms as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–5 5.1.2.3 VALUES Forms as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–9 5.1.2.4 THE Forms as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–9 5.1.2.5 APPLY Forms as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–9 5.1.2.6 Setf Expansions and Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–10 5.1.2.7 Macro Forms as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–10 5.1.2.8 Symbol Macros as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–10 5.1.2.9 Other Compound Forms as Places . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–10 5.1.3 Treatment of Other Macros Based on SETF . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–11 5.2 Transfer of Control to an Exit Point . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–13 5.3 Data and Control Flow Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5–14

Chapter 6 (Iteration)

6.1The LOOP Facility . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1 6.1.1Overview of the Loop Facility . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1 6.1.1.1Simple vs Extended Loop . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1 6.1.1.1.1Simple Loop . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1

6.1.1.1.2Extended Loop . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1 6.1.1.2Loop Keywords . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1 6.1.1.3Parsing Loop Clauses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–1 6.1.1.4 Expanding Loop Forms . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–2 6.1.1.5 Summary of Loop Clauses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–3 6.1.1.5.1 Summary of Variable Initialization and Stepping Clauses . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–3 6.1.1.5.2 Summary of Value Accumulation Clauses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–3 6.1.1.5.3 Summary of Termination 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6.1.6.1Examples of WHEN clause . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–25

6.1.7 Miscellaneous Clauses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–26 6.1.7.1Control Transfer Clauses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–27 6.1.7.1.1Examples of NAMED clause . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–27 6.1.7.2Initial and Final Execution . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–27 6.1.8Examples of Miscellaneous Loop Features . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–27 6.1.8.1Examples of clause grouping . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–28 6.1.9 Notes about Loop . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–30 6.2 Iteration Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6–31

Chapter 7 (Objects)

7.1 Object Creation and Initialization . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–1 7.1.1 Initialization Arguments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–2 7.1.2 Declaring the Validity of Initialization Arguments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–2 7.1.3 Defaulting of Initialization Arguments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–3 7.1.4 Rules for Initialization Arguments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–4 7.1.5 Shared-Initialize . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–5 7.1.6 Initialize-Instance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–6 7.1.7 Definitions of Make-Instance and Initialize-Instance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–7 7.2 Changing the Class of an Instance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–9 7.2.1 Modifying the Structure of the Instance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–9 7.2.2 Initializing Newly Added Local Slots . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–9 7.2.3 Customizing the Change of Class of an Instance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–10 7.3 Reinitializing an Instance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–11 7.3.1 Customizing Reinitialization . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–11 7.4 Meta-Objects . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–12 7.4.1 Standard Meta-objects . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–12 7.5 Slots . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–13 7.5.1 Introduction to Slots . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–13 7.5.2 Accessing Slots . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–13 7.5.3 Inheritance of Slots and Slot Options . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–14 7.6 Generic Functions and Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–16 7.6.1 Introduction to Generic Functions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–16 7.6.2 Introduction to Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–17 7.6.3 Agreement on Parameter Specializers and Qualifiers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–19 7.6.4 Congruent Lambda-lists for all Methods of a Generic Function . . . . . . . . . . . . . . . . . . . . . . . . . 7–19 7.6.5 Keyword Arguments in Generic Functions and Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–20 7.6.5.1 Examples of Keyword Arguments in Generic Functions and Methods . . . . . . . . . . . . . . . . . . . 7–20 7.6.6 Method Selection and Combination . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–21 7.6.6.1 Determining the Effective Method . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–21 7.6.6.1.1 Selecting the Applicable Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–21 7.6.6.1.2 Sorting the Applicable Methods by Precedence Order . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–22 7.6.6.1.3 Applying method combination to the sorted list of applicable methods . . . . . . . . . . . . . . . . . 7–22 7.6.6.2 Standard Method Combination . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–23 7.6.6.3 Declarative Method Combination . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–24 7.6.6.4 Built-in Method Combination Types . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–25

7.6.7 Inheritance of Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–26 7.7 Objects Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7–27

Chapter 8 (Structures)

8.1 Structures Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8–1

Chapter 9 (Conditions)

9.1 Condition System Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–1 9.1.1 Condition Types . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–2 9.1.1.1 Serious Conditions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–3 9.1.2 Creating Conditions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–3 9.1.2.1 Condition Designators . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–3 9.1.3 Printing Conditions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–4 9.1.3.1 Recommended Style in Condition Reporting . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–4 9.1.3.1.1Capitalization and Punctuation in Condition Reports . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–5 9.1.3.1.2Leading and Trailing Newlines in Condition Reports . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–5 9.1.3.1.3Embedded Newlines in Condition Reports . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–5 9.1.3.1.4 Note about Tabs in Condition Reports . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–6 9.1.3.1.5 Mentioning Containing Function in Condition Reports . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–6 9.1.4 Signaling and Handling Conditions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–6 9.1.4.1 Signaling . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–7 9.1.4.1.1 Resignaling a Condition . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–7 9.1.4.2 Restarts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–8 9.1.4.2.1 Interactive Use of Restarts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–9 9.1.4.2.2 Interfaces to Restarts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–9 9.1.4.2.3 Restart Tests . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–9 9.1.4.2.4 Associating a Restart with a Condition . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–9 9.1.5 Assertions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–10 9.1.6 Notes about the Condition System’s Background . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–10 9.2 Conditions Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9–11

Chapter 10 (Symbols)

10.1 Symbol Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10–1 10.2 Symbols Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10–2

Chapter 11 (Packages)

11.1 Package Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–1 11.1.1 Introduction to Packages . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–1 11.1.1.1 Package Names and Nicknames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–1 11.1.1.2 Symbols in a Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–1 11.1.1.2.1 Internal and External Symbols . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–1 11.1.1.2.2 Package Inheritance . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–2 11.1.1.2.3 Accessibility of Symbols in a Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–2

11.1.1.2.4 Locating a Symbol in a Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–3 11.1.1.2.5 Prevention of Name Conflicts in Packages . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–3 11.1.2 Standardized Packages . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–4 11.1.2.1 The COMMON-LISP Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–4 11.1.2.1.1 Constraints on the COMMON-LISP Package for Conforming Implementations . . . . . . . . . . 11–5 11.1.2.1.2 Constraints on the COMMON-LISP Package for Conforming Programs . . . . . . . . . . . . . . . 11–5 11.1.2.1.2.1 Some Exceptions to Constraints on the COMMON-LISP Package for Conforming

Programs . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–6 11.1.2.2 The COMMON-LISP-USER Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–6 11.1.2.3 The KEYWORD Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–7 11.1.2.3.1 Interning a Symbol in the KEYWORD Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–7 11.1.2.3.2 Notes about The KEYWORD Package . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–7 11.1.2.4 Implementation-Defined Packages . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–7 11.2 Packages Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11–8

Chapter 12 (Numbers)

12.1 Number Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–1 12.1.1 Numeric Operations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–1 12.1.1.1 Associativity and Commutativity in Numeric Operations . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–2 12.1.1.1.1 Examples of Associativity and Commutativity in Numeric Operations . . . . . . . . . . . . . . . . 12–2 12.1.1.2 Contagion in Numeric Operations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–3 12.1.1.3 Viewing Integers as Bits and Bytes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–3 12.1.1.3.1 Logical Operations on Integers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–3 12.1.1.3.2 Byte Operations on Integers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–3 12.1.2 Implementation-Dependent Numeric Constants . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–4 12.1.3 Rational Computations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–4 12.1.3.1 Rule of Unbounded Rational Precision . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–4 12.1.3.2 Rule of Canonical Representation for Rationals . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–5 12.1.3.3 Rule of Float Substitutability . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–5 12.1.4Floating-point Computations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–6 12.1.4.1Rule of Float and Rational Contagion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–6 12.1.4.1.1Examples of Rule of Float and Rational Contagion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–6 12.1.4.2 Rule of Float Approximation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–7 12.1.4.3 Rule of Float Underflow and Overflow . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–7 12.1.4.4 Rule of Float Precision Contagion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–7 12.1.5 Complex Computations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–7 12.1.5.1 Rule of Complex Substitutability . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–8 12.1.5.2 Rule of Complex Contagion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–8 12.1.5.3 Rule of Canonical Representation for Complex Rationals . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–8 12.1.5.3.1 Examples of Rule of Canonical Representation for Complex Rationals . . . . . . . . . . . . . . . . . 12–8 12.1.5.4 Principal Values and Branch Cuts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–8 12.1.6 Interval Designators . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–9 12.1.7 Random-State Operations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–10 12.2 Numbers Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12–11

Chapter 13 (Characters)

13.1 Character Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–1 13.1.1 Introduction to Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–1 13.1.2 Introduction to Scripts and Repertoires . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–1 13.1.2.1 Character Scripts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–1 13.1.2.2 Character Repertoires . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–2 13.1.3 Character Attributes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–2 13.1.4 Character Categories . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–2 13.1.4.1 Graphic Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–3 13.1.4.2 Alphabetic Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–3 13.1.4.3 Characters With Case . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–3 13.1.4.3.1 Uppercase Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–3 13.1.4.3.2 Lowercase Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–4 13.1.4.3.3 Corresponding Characters in the Other Case . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–4 13.1.4.3.4 Case of Implementation-Defined Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–4 13.1.4.4 Numeric Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–4 13.1.4.5 Alphanumeric Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–4 13.1.4.6 Digits in a Radix . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–4 13.1.5 Identity of Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–5 13.1.6 Ordering of Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–5 13.1.7 Character Names . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–5 13.1.8 Treatment of Newline during Input and Output . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–6 13.1.9 Character Encodings . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–7 13.1.10 Documentation of Implementation-Defined Scripts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–7 13.2 Characters Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13–8

Chapter 14 (Conses)

14.1 Cons Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–1 14.1.1 Conses as Trees . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–1 14.1.1.1 General Restrictions on Parameters that must be Trees . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–1 14.1.2 Conses as Lists . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–1 14.1.2.1 Lists as Association Lists . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–2 14.1.2.2 Lists as Sets . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–2 14.1.2.3 General Restrictions on Parameters that must be Lists . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–3 14.2 Conses Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14–4

Chapter 15 (Arrays)

15.1 Array Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1 Array Elements . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1.1 Array Indices . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1.2 Array Dimensions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1.2.1 Implementation Limits on Individual Array Dimensions . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1.3 Array Rank . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1.3.1 Vectors . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1

15.1.1.3.1.1 Fill Pointers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–1 15.1.1.3.2 Multidimensional Arrays . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–2 15.1.1.3.2.1 Storage Layout for Multidimensional Arrays . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–2 15.1.1.3.2.2 Implementation Limits on Array Rank . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–2 15.1.2 Specialized Arrays . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–2 15.1.2.1 Array Upgrading . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–3 15.1.2.2 Required Kinds of Specialized Arrays . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–3 15.2 Arrays Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15–5

Chapter 16 (Strings)

16.1 String Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16–1 16.1.1 Implications of Strings Being Arrays . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16–1 16.1.2 Subtypes of STRING . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16–1 16.2 Strings Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16–2

Chapter 17 (Sequences)

17.1 Sequence Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–1 17.1.1 General Restrictions on Parameters that must be Sequences . . . . . . . . . . . . . . . . . . . . . . . . . . 17–1 17.2Rules about Test Functions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–2 17.2.1Satisfying a Two-Argument Test . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–2 17.2.1.1Examples of Satisfying a Two-Argument Test . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–2 17.2.2 Satisfying a One-Argument Test . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–3 17.2.2.1 Examples of Satisfying a One-Argument Test . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–4 17.3 Sequences Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 17–5

Chapter 18 (Hash Tables)

18.1 Hash Table Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–1 18.1.1 Hash-Table Operations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–1 18.1.2 Modifying Hash Table Keys . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–1 18.1.2.1 Visible Modification of Objects with respect to EQ and EQL . . . . . . . . . . . . . . . . . . . . . . . . 18–2 18.1.2.2 Visible Modification of Objects with respect to EQUAL . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–2 18.1.2.2.1 Visible Modification of Conses with respect to EQUAL . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–2 18.1.2.2.2 Visible Modification of Bit Vectors and Strings with respect to EQUAL . . . . . . . . . . . . . . . 18–2 18.1.2.3 Visible Modification of Objects with respect to EQUALP . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–2 18.1.2.3.1 Visible Modification of Structures with respect to EQUALP . . . . . . . . . . . . . . . . . . . . . . . . 18–2 18.1.2.3.2 Visible Modification of Arrays with respect to EQUALP . . . . . . . . . . . . . . . . . . . . . . . . . . 18–3 18.1.2.3.3 Visible Modification of Hash Tables with respect to EQUALP . . . . . . . . . . . . . . . . . . . . . . 18–3 18.1.2.4 Visible Modifications by Language Extensions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–3 18.2 Hash Tables Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18–4

Chapter 19 (Filenames)

19.1 Overview of Filenames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–1 19.1.1 Namestrings as Filenames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–1

19.1.2 Pathnames as Filenames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–1 19.1.3 Parsing Namestrings Into Pathnames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–2 19.2 Pathnames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1 Pathname Components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1.1 The Pathname Host Component . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1.2 The Pathname Device Component . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1.3 The Pathname Directory Component . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1.4 The Pathname Name Component . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1.5 The Pathname Type Component . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.1.6 The Pathname Version Component . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.2 Interpreting Pathname Component Values . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.2.1 Strings in Component Values . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–3 19.2.2.1.1 Special Characters in Pathname Components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–4 19.2.2.1.2 Case in Pathname Components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–4 19.2.2.1.2.1 Local Case in Pathname Components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–4 19.2.2.1.2.2 Common Case in Pathname Components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–4 19.2.2.2 Special Pathname Component Values . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–5 19.2.2.2.1 NIL as a Component Value . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–5 19.2.2.2.2 :WILD as a Component Value . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–5 19.2.2.2.3 :UNSPECIFIC as a Component Value . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–5 19.2.2.2.3.1 Relation between component values NIL and :UNSPECIFIC . . . . . . . . . . . . . . . . . . . . . . 19–6 19.2.2.3 Restrictions on Wildcard Pathnames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–6 19.2.2.4 Restrictions on Examining Pathname Components . . . . . . . . . . . . . . . . . . . . . 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19.3.2 Logical Pathname Components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–14 19.3.2.1 Unspecific Components of a Logical Pathname . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–14 19.3.2.2 Null Strings as Components of a Logical Pathname . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–14 19.4 Filenames Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19–15

Chapter 20 (Files)

20.1 File System Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20–1 20.1.1 Coercion of Streams to Pathnames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20–1 20.1.2 File Operations on Open and Closed Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20–1 20.1.3 Truenames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20–2 20.1.3.1 Examples of Truenames . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20–2 20.2 Files Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20–3

Chapter 21 (Streams)

21.1 Stream Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–1 21.1.1 Introduction to Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–1 21.1.1.1 Abstract Classifications of Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–1 21.1.1.1.1 Input, Output, and Bidirectional Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–1 21.1.1.1.2 Open and Closed Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–2 21.1.1.1.3 Interactive Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–2 21.1.1.2 Abstract Classifications of Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–3 21.1.1.2.1 File Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–3 21.1.1.3 Other Subclasses of Stream . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–3 21.1.2 Stream Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–4 21.1.3 Stream Arguments to Standardized Functions . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–5 21.1.4 Restrictions on Composite Streams . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–6 21.2 Streams Dictionary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21–7

Chapter 22 (Printer)

22.1 The Lisp Printer . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–1 22.1.1 Overview of The Lisp Printer . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–1 22.1.1.1 Multiple Possible Textual Representations . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–1 22.1.1.1.1 Printer Escaping . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–2 22.1.2 Printer Dispatching . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–2 22.1.3 Default Print-Object Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–2 22.1.3.1 Printing Numbers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–2 22.1.3.1.1 Printing Integers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–2 22.1.3.1.2 Printing Ratios . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–3 22.1.3.1.3 Printing Floats . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–3 22.1.3.1.4 Printing Complexes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–3 22.1.3.1.5 Note about Printing Numbers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–3 22.1.3.2 Printing Characters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–4 22.1.3.3 Printing Symbols . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–4

22.1.3.3.1 Package Prefixes for Symbols . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–4 22.1.3.3.2 Effect of Readtable Case on the Lisp Printer . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–5 22.1.3.3.2.1Examples of Effect of Readtable Case on the Lisp Printer . . . . . . . . . . . . . . . . . . . . . . . . . 22–6 22.1.3.4Printing Strings . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–8 22.1.3.5Printing Lists and Conses . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–8 22.1.3.6 Printing Bit Vectors . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–9 22.1.3.7 Printing Other Vectors . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–9 22.1.3.8 Printing Other Arrays . . . 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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–14 22.2.1 Pretty Printer Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–14 22.2.1.1 Dynamic Control of the Arrangement of Output . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–14 22.2.1.2 Format Directive Interface . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–15 22.2.1.3Compiling Format Strings . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–16 22.2.1.4Pretty Print Dispatch Tables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–16 22.2.1.5Pretty Printer Margins . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–16 22.2.2Examples of using the Pretty Printer . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 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22.3.1.5 Tilde Tilde: Tilde . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–25 22.3.2 FORMAT Radix Control . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–25 22.3.2.1 Tilde R: Radix . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–25 22.3.2.2 Tilde D: Decimal . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–26 22.3.2.3 Tilde B: Binary . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–26 22.3.2.4 Tilde O: Octal . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–26 22.3.2.5 Tilde X: Hexadecimal . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22–27 22.3.3 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