axiom™

The 30 Year Horizon

Manuel Bronstein *William Burge* *Timothy Daly*
James Davenport *Michael Dewar* *Martin Dunstan*
Albrecht Fortenbacher *Patrizia Gianni* *Johannes Grabmeier*
Jocelyn Guidry *Richard Jenks* *Larry Lambe*
Michael Monagan *Scott Morrison* *William Sit*
Jonathan Steinbach *Robert Sutor* *Barry Trager*
Stephen Watt *Jim Wen* *Clifton Williamson*

Axiom Table of Contexts

Contents

Volume 0: Axiom *Jenks and Sutor*
Volume 1: Axiom *Tutorial*
Volume 2: Axiom *Users Guide*
Volume 3: Axiom *Programmers Guide*
Volume 4: Axiom *Developers Guide*
Volume 5: Axiom *Interpreter*
Volume 6: Axiom *Command*
Volume 7: Axiom *Hyperdoc*
Volume 7.1: Axiom *Hyperdoc Pages*
Volume 8: Axiom *Graphics*
Volume 8.1: Axiom *Gallery*
Volume 9: Axiom *Compiler*
Volume 10: Axiom *Algebra: Implementation*
Volume 10.1: Axiom *Algebra: Theory*
Volume 10.2: Axiom *Algebra: Categories*
Volume 10.3: Axiom *Algebra: Domains*
Volume 10.4: Axiom *Algebra: Packages*
Volume 10.5: Axiom *Algebra: Numerics*
Volume 11: Axiom *Browser*
Volume 12: Axiom *Crystal*
Volume 13: Axiom *Proving Axiom Correct*
Bibliography: Axiom *Bibliography*

Volume 0: Axiom Jenks and Sutor

Contributors **xxv**
Obituary – Richard Dimick Jenks . . . xxv
Obituary – James Griesmer . . . xxviii
Obituary – Manuel Bronstein . . . xxx
Obituary – Christine Jeanne O'Connor . . . xxxv
Obituary – William Frederick Schelter . . . xxxvii

Introduction to Axiom **1**
0.0.1 Symbolic Computation . . . 1
0.0.2 Numeric Computation . . . 2
0.0.3 Graphics . . . 2
0.0.4 HyperDoc . . . 3
0.0.5 Interactive Programming . . . 3
0.0.6 Data Structures . . . 5
0.0.7 Mathematical Structures . . . 6
0.0.8 Pattern Matching . . . 7
0.0.9 Polymorphic Algorithms . . . 7
0.0.10 Extensibility . . . 8

A Technical Introduction to AXIOM **9**
0.1 Types are Defined by Abstract Datatype Programs . . . 9
0.2 The Type of Basic Objects is a Domain or Subdomain . . . 10
0.3 Domains Have Types Called Categories . . . 10
0.4 Operations Can Refer To Abstract Types . . . 11
0.5 Categories Form Hierarchies . . . 11
0.6 Domains Belong to Categories by Assertion . . . 12
0.7 Packages Are Clusters of Polymorphic Operations . . . 12
0.8 The Interpreter Builds Domains Dynamically . . . 13
0.9 Axiom Code is Compiled . . . 13
0.10 Axiom is Extensible . . . 14
0.11 Using Axiom as a Pocket Calculator . . . 14
0.11.1 Basic Arithmetic . . . 14
0.11.2 Type Conversion . . . 15
0.11.3 Useful Functions . . . 17
0.12 Using Axiom as a Symbolic Calculator . . . 19
0.12.1 Expressions Involving Symbols . . . 19
0.12.2 Complex Numbers . . . 20
0.12.3 Number Representations . . . 21
0.12.4 Modular Arithmetic . . . 24
0.13 General Points about Axiom . . . 25
0.13.1 Computation Without Output . . . 25
0.13.2 Accessing Earlier Results . . . 25
0.13.3 Splitting Expressions Over Several Lines . . . 25

0.13.4 Comments and Descriptions . . . 26
0.13.5 Control of Result Types . . . 26
0.14 Data Structures in Axiom . . . 27
0.14.1 Lists . . . 27
0.14.2 Segmented Lists . . . 33
0.14.3 Streams . . . 33
0.14.4 Arrays, Vectors, Strings, and Bits . . . 35
0.14.5 Flexible Arrays . . . 37
0.15 Functions, Choices, and Loops . . . 38
0.15.1 Reading Code from a File . . . 39
0.15.2 Blocks . . . 39
0.15.3 Functions . . . 42
0.15.4 Choices . . . 43
0.15.5 Loops . . . 44

An Overview of Axiom **51**
1.1 Starting Up and Winding Down . . . 51
1.1.1 Clef . . . 52
1.2 Typographic Conventions . . . 52
1.3 The Axiom Language . . . 53
1.3.1 Arithmetic Expressions . . . 53
1.3.2 Previous Results . . . 54
1.3.3 Some Types . . . 54
1.3.4 Symbols, Variables, Assignments, and Declarations . . . 55
1.3.5 Conversion . . . 57
1.3.6 Calling Functions . . . 58
1.3.7 Some Predefined Macros . . . 58
1.3.8 Long Lines . . . 59
1.3.9 Comments . . . 59
1.4 Numbers . . . 59
1.5 Data Structures . . . 65
1.6 Expanding to Higher Dimensions . . . 71
1.7 Writing Your Own Functions . . . 72
1.8 Polynomials . . . 76
1.9 Limits . . . 77
1.10 Series . . . 78
1.11 Derivatives . . . 80
1.12 Integration . . . 82
1.13 Differential Equations . . . 85
1.14 Solution of Equations . . . 87
1.15 System Commands . . . 88
1.15.1 Undo . . . 89
1.16 Graphics . . . 91

Using Types and Modes **95**
2.1 The Basic Idea . . . 95
2.1.1 Domain Constructors . . . 96
2.2 Writing Types and Modes . . . 101
2.2.1 Types with No Arguments . . . 101
2.2.2 Types with One Argument . . . 102
2.2.3 Types with More Than One Argument . . . 103
2.2.4 Modes . . . 103
2.2.5 Abbreviations . . . 103
2.3 Declarations . . . 105
2.4 Records . . . 107
2.5 Unions . . . 109
2.5.1 Unions Without Selectors . . . 109
2.5.2 Unions With Selectors . . . 112
2.6 The "Any" Domain . . . 113
2.7 Conversion . . . 114
2.8 Subdomains Again . . . 116
2.9 Package Calling and Target Types . . . 118
2.10 Resolving Types . . . 121
2.11 Exposing Domains and Packages . . . 123
2.12 Commands for Snooping . . . 125

Using HyperDoc **129**
chapter*.10
3.1 Headings . . . 129
3.2 Key Definitions . . . 130
3.3 Scroll Bars . . . 130
3.4 Input Areas . . . 131
3.5 Radio Buttons and Toggles . . . 131
3.6 Search Strings . . . 131
3.6.1 Logical Searches . . . 132
3.7 Example Pages . . . 132
3.8 X Window Resources for HyperDoc . . . 133

Input Files and Output Styles **135**
chapter*.11
4.1 Input Files . . . 135
4.2 The .axiom.input File . . . 136
4.3 Common Features of Using Output Formats . . . 136
4.4 Monospace Two-Dimensional Mathematical Format . . . 137
4.5 TeX Format . . . 138
4.6 IBM Script Formula Format . . . 139
4.7 FORTRAN Format . . . 139

Overview of Interactive Language **143**
chapter*.12
5.1 Immediate and Delayed Assignments . . . 143
5.2 Blocks . . . 146
5.3 if-then-else . . . 148
5.4 Loops . . . 150
5.4.1 Compiling vs. Interpreting Loops . . . 150
5.4.2 return in Loops . . . 151
5.4.3 break in Loops . . . 152
5.4.4 break vs. => in Loop Bodies . . . 152
5.4.5 More Examples of break . . . 153
5.4.6 iterate in Loops . . . 155
5.4.7 while Loops . . . 155
5.4.8 for Loops . . . 157
5.4.9 for i in n..m repeat . . . 158
5.4.10 for i in n..m by s repeat . . . 159
5.4.11 for i in n.. repeat . . . 160
5.4.12 for x in l repeat . . . 160
5.4.13 "Such that" Predicates . . . 161
5.4.14 Parallel Iteration . . . 162
5.4.15 Mixing Loop Modifiers . . . 163
5.5 Creating Lists and Streams with Iterators . . . 164
5.6 An Example: Streams of Primes . . . 166

User-Defined Functions, Macros and Rules **169**
6.1 Functions vs. Macros . . . 169
6.2 Macros . . . 170
6.3 Introduction to Functions . . . 172
6.4 Declaring the Type of Functions . . . 173
6.5 One-Line Functions . . . 174
6.6 Declared vs. Undeclared Functions . . . 175
6.7 Functions vs. Operations . . . 177
6.8 Delayed Assignments vs. Functions with No Arguments . . . 178
6.9 How Axiom Determines What Function to Use . . . 178
6.10 Compiling vs. Interpreting . . . 180
6.11 Piece-Wise Function Definitions . . . 181
6.11.1 A Basic Example . . . 182
6.11.2 Picking Up the Pieces . . . 184
6.11.3 Predicates . . . 186
6.12 Caching Previously Computed Results . . . 187
6.13 Recurrence Relations . . . 188
6.14 Making Functions from Objects . . . 190
6.15 Functions Defined with Blocks . . . 193
6.16 Free and Local Variables . . . 195
6.17 Anonymous Functions . . . 200
6.17.1 Some Examples . . . 200

6.17.2 Declaring Anonymous Functions . . . 202
6.18 Example: A Database . . . 203
6.19 Example: A Famous Triangle . . . 205
6.20 Example: Testing for Palindromes . . . 207
6.21 Rules and Pattern Matching . . . 209

Graphics **215**
chapter*.14
7.1 Two-Dimensional Graphics . . . 215
7.1.1 Plotting Two-Dimensional Functions of One Variable . . . 216
7.1.2 Plotting Two-Dimensional Parametric Plane Curves . . . 217
7.1.3 Plotting Plane Algebraic Curves . . . 220
7.1.4 Two-Dimensional Options . . . 220
7.1.5 Color . . . 224
7.1.6 Palette . . . 225
7.1.7 Two-Dimensional Control-Panel . . . 226
7.1.8 Operations for Two-Dimensional Graphics . . . 229
7.1.9 Addendum: Building Two-Dimensional Graphs . . . 231
7.1.10 Addendum: Appending a Graph to a Viewport Window Containing a Graph . . . 236
7.2 Three-Dimensional Graphics . . . 237
7.2.1 Plotting Three-Dimensional Functions of Two Variables . . . 237
7.2.2 Plotting Three-Dimensional Parametric Space Curves . . . 238
7.2.3 Plotting Three-Dimensional Parametric Surfaces . . . 239
7.2.4 Axiom Images . . . 241
7.2.5 Three-Dimensional Options . . . 250
7.2.6 The makeObject Command . . . 255
7.2.7 Building Three-Dimensional Objects From Primitives . . . 256
7.2.8 Coordinate System Transformations . . . 260
7.2.9 Three-Dimensional Clipping . . . 263
7.2.10 Three-Dimensional Control-Panel . . . 264
7.2.11 Operations for Three-Dimensional Graphics . . . 268
7.2.12 Customization using .Xdefaults . . . 271

Advanced Problem Solving **273**
chapter*.28
8.1 Numeric Functions . . . 273
8.2 Polynomial Factorization . . . 283
8.2.1 Integer and Rational Number Coefficients . . . 283
8.2.2 Finite Field Coefficients . . . 284
8.2.3 Simple Algebraic Extension Field Coefficients . . . 284
8.2.4 Factoring Rational Functions . . . 286
8.3 Manipulating Symbolic Roots of a Polynomial . . . 286
8.3.1 Using a Single Root of a Polynomial . . . 286
8.3.2 Using All Roots of a Polynomial . . . 288
8.4 Computation of Eigenvalues and Eigenvectors . . . 289

8.5 Solution of Linear and Polynomial Equations . . . 292
8.5.1 Solution of Systems of Linear Equations . . . 292
8.5.2 Solution of a Single Polynomial Equation . . . 294
8.5.3 Solution of Systems of Polynomial Equations . . . 295
8.6 Limits . . . 297
8.7 Laplace Transforms . . . 300
8.8 Integration . . . 301
8.9 Working with Power Series . . . 304
8.9.1 Creation of Power Series . . . 304
8.9.2 Coefficients of Power Series . . . 306
8.9.3 Power Series Arithmetic . . . 307
8.9.4 Functions on Power Series . . . 308
8.9.5 Converting to Power Series . . . 310
8.9.6 Power Series from Formulas . . . 313
8.9.7 Substituting Numerical Values in Power Series . . . 316
8.9.8 Example: Bernoulli Polynomials and Sums of Powers . . . 316
8.10 Solution of Differential Equations . . . 319
8.10.1 Closed-Form Solutions of Linear Differential Equations . . . 319
8.10.2 Closed-Form Solutions of Non-Linear Differential Equations . . . 322
8.10.3 Power Series Solutions of Differential Equations . . . 325
8.11 Finite Fields . . . 327
8.11.1 Modular Arithmetic and Prime Fields . . . 327
8.11.2 Extensions of Finite Fields . . . 330
8.11.3 Irreducible Modulus Polynomial Representations . . . 331
8.11.4 Cyclic Group Representations . . . 334
8.11.5 Normal Basis Representations . . . 336
8.11.6 Conversion Operations for Finite Fields . . . 338
8.11.7 Utility Operations for Finite Fields . . . 340
8.12 Primary Decomposition of Ideals . . . 345
8.13 Computation of Galois Groups . . . 347
8.14 Non-Associative Algebras and Modelling Genetic Laws . . . 354

Some Examples of Domains and Packages **359**
chapter*.29
9.1 ApplicationProgramInterface . . . 359
9.2 ArrayStack . . . 360
9.3 AssociationList . . . 363
9.4 BalancedBinaryTree . . . 365
9.5 BasicOperator . . . 366
9.6 BinaryExpansion . . . 369
9.7 BinarySearchTree . . . 370
9.8 CardinalNumber . . . 372
9.9 CartesianTensor . . . 375
9.10 Character . . . 383
9.11 CharacterClass . . . 385
9.12 CliffordAlgebra . . . 387

9.12.1 The Complex Numbers as a Clifford Algebra . . . 387
9.12.2 The Quaternion Numbers as a Clifford Algebra . . . 388
9.12.3 The Exterior Algebra on a Three Space . . . 389
9.12.4 The Dirac Spin Algebra . . . 391
9.13 Complex . . . 392
9.14 ContinuedFraction . . . 394
9.15 CycleIndicators . . . 399
9.16 DeRhamComplex . . . 407
9.17 DecimalExpansion . . . 411
9.18 Dequeue . . . 413
9.19 DistributedMultivariatePolynomial . . . 417
9.20 DoubleFloat . . . 419
9.21 EqTable . . . 421
9.22 Equation . . . 422
9.23 EuclideanGroebnerBasisPackage . . . 423
9.24 Exit . . . 424
9.25 Expression . . . 425
9.26 Factored . . . 429
9.26.1 Decomposing Factored Objects . . . 429
9.26.2 Expanding Factored Objects . . . 430
9.26.3 Arithmetic with Factored Objects . . . 431
9.26.4 Creating New Factored Objects . . . 433
9.26.5 Factored Objects with Variables . . . 434
9.27 FactoredFunctions2 . . . 434
9.28 File . . . 435
9.29 FileName . . . 437
9.30 FlexibleArray . . . 439
9.31 Float . . . 442
9.31.1 Introduction to Float . . . 442
9.31.2 Conversion Functions . . . 443
9.31.3 Output Functions . . . 445
9.31.4 An Example: Determinant of a Hilbert Matrix . . . 446
9.32 Fraction . . . 447
9.33 FullPartialFractionExpansion . . . 449
9.34 GeneralDistributedMultivariatePolynomial . . . 453
9.35 GeneralSparseTable . . . 455
9.36 GroebnerFactorizationPackage . . . 456
9.37 GroebnerPackage . . . 457
9.38 Heap . . . 458
9.39 HexadecimalExpansion . . . 459
9.40 HomogeneousDistributedMultivariatePolynomial . . . 460
9.41 Integer . . . 462
9.41.1 Basic Functions . . . 462
9.41.2 Primes and Factorization . . . 466
9.41.3 Some Number Theoretic Functions . . . 467
9.42 IntegerLinearDependence . . . 469

9.43 IntegerNumberTheoryFunctions . . . 470
9.44 Kernel . . . 474
9.45 KeyedAccessFile . . . 477
9.46 LexTriangularPackage . . . 479
9.47 LazardSetSolvingPackage . . . 503
9.48 Library . . . 512
9.49 LieExponentials . . . 513
9.50 LiePolynomial . . . 515
9.51 LinearOrdinaryDifferentialOperator . . . 518
9.51.1 Differential Operators with Series Coefficients . . . 518
9.52 LinearOrdinaryDifferentialOperator1 . . . 521
9.52.1 Differential Operators with Rational Function Coefficients . . . 522
9.53 LinearOrdinaryDifferentialOperator2 . . . 525
9.53.1 Differential Operators with Constant Coefficients . . . 525
9.53.2 Differential Operators with Matrix Coefficients Operating on Vectors 527
9.54 List . . . 529
9.54.1 Creating Lists . . . 530
9.54.2 Accessing List Elements . . . 530
9.54.3 Changing List Elements . . . 532
9.54.4 Other Functions . . . 533
9.54.5 Dot, Dot . . . 534
9.55 LyndonWord . . . 535
9.56 Magma . . . 537
9.57 MakeFunction . . . 539
9.58 MappingPackage1 . . . 541
9.59 Matrix . . . 545
9.59.1 Creating Matrices . . . 545
9.59.2 Operations on Matrices . . . 549
9.60 Multiset . . . 552
9.61 MultivariatePolynomial . . . 554
9.62 None . . . 556
9.63 NottinghamGroup . . . 556
9.64 Octonion . . . 557
9.65 OneDimensionalArray . . . 559
9.66 Operator . . . 560
9.67 OrderedVariableList . . . 563
9.68 OrderlyDifferentialPolynomial . . . 564
9.69 PartialFraction . . . 569
9.70 Permanent . . . 572
9.71 Permutation . . . 572
9.72 Polynomial . . . 573
9.73 Quaternion . . . 580
9.74 Queue . . . 582
9.75 RadixExpansion . . . 583
9.76 RealClosure . . . 586
9.77 RealSolvePackage . . . 595

9.78 RegularTriangularSet . . . 597
9.79 RomanNumeral . . . 609
9.80 Segment . . . 611
9.81 SegmentBinding . . . 612
9.82 Set . . . 613
9.83 SingleInteger . . . 616
9.84 SparseTable . . . 618
9.85 SquareMatrix . . . 619
9.86 SquareFreeRegularTriangularSet . . . 620
9.87 Stack . . . 624
9.88 Stream . . . 626
9.89 String . . . 628
9.90 StringTable . . . 632
9.91 Symbol . . . 633
9.92 Table . . . 636
9.93 TextFile . . . 638
9.94 TwoDimensionalArray . . . 640
9.95 TwoDimensionalViewport . . . 643
9.96 UnaryRecursiveAggregate . . . 650
9.97 UnivariatePolynomial . . . 657
9.98 UnivariateSkewPolynomial . . . 662
9.98.1 A second example . . . 664
9.98.2 A third example . . . 665
9.98.3 A fourth example . . . 666
9.99 UniversalSegment . . . 666
9.100Vector . . . 668
9.101Void . . . 669
9.102WuWenTsunTriangularSet . . . 670
9.103XPBWPolynomial . . . 673
9.104XPolynomial . . . 678
9.105XPolynomialRing . . . 680
9.106ZeroDimensionalSolvePackage . . . 683

Interactive Programming **709**
chapter*.39
10.1 Drawing Ribbons Interactively . . . 709
10.2 A Ribbon Program . . . 714
10.3 Coloring and Positioning Ribbons . . . 715
10.4 Points, Lines, and Curves . . . 716
10.5 A Bouquet of Arrows . . . 718
10.6 Diversion: When Things Go Wrong . . . 719
10.7 Drawing Complex Vector Fields . . . 719
10.8 Drawing Complex Functions . . . 721
10.9 Functions Producing Functions . . . 723
10.10Automatic Newton Iteration Formulas . . . 723

Packages **727**
chapter*.40
11.1 Names, Abbreviations, and File Structure . . . 727
11.2 Syntax . . . 729
11.3 Abstract Datatypes . . . 729
11.4 Capsules . . . 730
11.5 Input Files vs. Packages . . . 730
11.6 Compiling Packages . . . 731
11.7 Parameters . . . 732
11.8 Conditionals . . . 734
11.9 Testing . . . 735
11.10How Packages Work . . . 736

Categories **739**
chapter*.41
12.1 Definitions . . . 739
12.2 Exports . . . 740
12.3 Documentation . . . 741
12.4 Hierarchies . . . 742
12.5 Membership . . . 742
12.6 Defaults . . . 743
12.7 Axioms . . . 744
12.8 Correctness . . . 744
12.9 Attributes . . . 745
12.10Parameters . . . 746
12.11Conditionals . . . 746
12.12Anonymous Categories . . . 747

Domains **749**
chapter*.42
13.1 Domains vs. Packages . . . 749
13.2 Definitions . . . 749
13.3 Category Assertions . . . 751
13.4 A Demo . . . 751
13.5 Browse . . . 752
13.6 Representation . . . 753
13.7 Multiple Representations . . . 753
13.8 Add Domain . . . 754
13.9 Defaults . . . 754
13.10Origins . . . 755
13.11Short Forms . . . 755
13.12Example 1: Clifford Algebra . . . 756
13.13Example 2: Building A Query Facility . . . 757
13.13.1 A Little Query Language . . . 758
13.13.2 The Database Constructor . . . 759
13.13.3 Query Equations . . . 760

13.13.4 DataLists . . . 761
13.13.5 Index Cards . . . 761
13.13.6 Creating a Database . . . 762
13.13.7 Putting It All Together . . . 762
13.13.8 Example Queries . . . 763

Browse **765**
chapter*.43
14.1 The Front Page: Searching the Library . . . 765
14.2 The Constructor Page . . . 767
14.2.1 Constructor Page Buttons . . . 769
14.2.2 Cross Reference . . . 771
14.2.3 Views Of Constructors . . . 773
14.2.4 Giving Parameters to Constructors . . . 775
14.3 Miscellaneous Features of Browse . . . 775
14.3.1 The Description Page for Operations . . . 775
14.3.2 Views of Operations . . . 776
14.3.3 Capitalization Convention . . . 779

What's New in Axiom Version 2.0 **781**
chapter*.91
14.4 Important Things to Read First . . . 781
14.5 The NAG Library Link . . . 781
14.5.1 Interpreting NAG Documentation . . . 781
14.5.2 Using the Link . . . 783
14.5.3 Providing values for Argument Subprograms . . . 784
14.5.4 General Fortran-generation utilities in Axiom . . . 785
14.5.5 Some technical information . . . 792
14.6 Interactive Front-end and Language . . . 792
14.7 Library . . . 793
14.8 HyperTex . . . 794
14.9 Documentation . . . 794

Axiom System Commands **797**
A.1 Introduction . . . 797
A.2)abbreviation . . . 798
A.3)browse . . . 799
A.4)cd . . . 800
A.5)clear . . . 800
A.6)close . . . 801
A.7)compile . . . 802
A.8)copyright . . . 804
A.9)credits . . . 804
A.10)describe . . . 804
A.11)display . . . 805
A.12)edit . . . 806

A.13)fin . . . 806
A.14)frame . . . 807
A.15)help . . . 808
A.16)history . . . 808
A.17)include . . . 810
A.18)library . . . 811
A.19)lisp . . . 811
A.20)ltrace . . . 812
A.21)pquit . . . 812
A.22)quit . . . 813
A.23)read . . . 813
A.24)regress . . . 814
A.25)savesystem . . . 817
A.26)set . . . 817
A.27)show . . . 818
A.28)spool . . . 819
A.29)summary . . . 819
A.30)synonym . . . 820
A.31)system . . . 821
A.32)tangle . . . 821
A.33)trace . . . 821
A.34)trace . . . 822
A.35)undo . . . 825
A.36)what . . . 826

Categories **829**

Domains **839**

Packages **869**

Operations **883**

Programs for Axiom Images **997**
F.1 images1.input . . . 997
F.2 images2.input . . . 998
F.3 images3.input . . . 998
F.4 images5.input . . . 998
F.5 images6.input . . . 999
F.6 images7.input . . . 1000
F.7 images8.input . . . 1000
F.8 conformal.input . . . 1001
F.9 tknot.input . . . 1004
F.10 ntube.input . . . 1004
F.11 dhtri.input . . . 1006
F.12 tetra.input . . . 1007

F.13 antoine.input 1008
F.14 scherk.input 1009

Glossary **1011**

BackMatter Quotes **1029**

License **1031**

Bibliography **1033**

Index **1035**

Volume 1: Axiom Tutorial

1 Axiom Features **1**
1.1 Introduction to Axiom . . . 1
1.1.1 Symbolic Computation . . . 1
1.1.2 Numeric Computation . . . 2
1.1.3 Mathematical Structures . . . 2
1.1.4 HyperDoc . . . 3
1.1.5 Interactive Programming . . . 3
1.1.6 Graphics . . . 5
1.1.7 Data Structures . . . 5
1.1.8 Pattern Matching . . . 7
1.1.9 Polymorphic Algorithms . . . 8
1.1.10 Extensibility . . . 9
1.1.11 Open Source . . . 9

2 Ten Fundamental Ideas **11**
2.0.12 Types are Defined by Abstract Datatype Programs . . . 11
2.0.13 The Type of Basic Objects is a Domain or Subdomain . . . 12
2.0.14 Domains Have Types Called Categories . . . 12
2.0.15 Operations Can Refer To Abstract Types . . . 13
2.0.16 Categories Form Hierarchies . . . 13
2.0.17 Domains Belong to Categories by Assertion . . . 13
2.0.18 Packages Are Clusters of Polymorphic Operations . . . 14
2.0.19 The Interpreter Builds Domains Dynamically . . . 14
2.0.20 Axiom Code is Compiled . . . 15
2.0.21 Axiom is Extensible . . . 15

3 Starting Axiom **17**
3.1 Starting Up and Winding Down . . . 17
3.1.1 Clef . . . 18
3.1.2 Typographic Conventions . . . 18
3.2 The Axiom Language . . . 19
3.2.1 Arithmetic Expressions . . . 19
3.2.2 Previous Results . . . 19
3.2.3 Some Types . . . 20
3.2.4 Symbols, Variables, Assignments, and Declarations . . . 21
3.2.5 Conversion . . . 23
3.2.6 Calling Functions . . . 23
3.2.7 Some Predefined Macros . . . 24
3.2.8 Long Lines . . . 24
3.2.9 Comments . . . 25
3.3 Using Axiom as a Pocket Calculator . . . 25
3.3.1 Basic Arithmetic . . . 25
3.3.2 Type Conversion . . . 26

3.3.3 Useful Functions . . . 28
3.4 Using Axiom as a Symbolic Calculator . . . 30
3.4.1 Expressions Involving Symbols . . . 30
3.4.2 Complex Numbers . . . 31
3.4.3 Number Representations . . . 32
3.4.4 Modular Arithmetic . . . 35
3.5 General Points about Axiom . . . 36
3.5.1 Computation Without Output . . . 36
3.5.2 Accessing Earlier Results . . . 36
3.5.3 Splitting Expressions Over Several Lines . . . 36
3.5.4 Comments and Descriptions . . . 37
3.5.5 Control of Result Types . . . 37
3.5.6 Using system commands . . . 38
3.5.7 Using undo . . . 39
3.6 Data Structures in Axiom . . . 41
3.6.1 Lists . . . 41
3.6.2 Segmented Lists . . . 47
3.6.3 Streams . . . 47
3.6.4 Arrays, Vectors, Strings, and Bits . . . 49
3.6.5 Flexible Arrays . . . 51
3.7 Functions, Choices, and Loops . . . 53
3.7.1 Reading Code from a File . . . 53
3.7.2 Blocks . . . 53
3.7.3 Functions . . . 56
3.7.4 Choices . . . 58
3.7.5 Loops . . . 58
3.8 Numbers . . . 66
3.9 Data Structures . . . 71
3.10 Expanding to Higher Dimensions . . . 76
3.11 Writing Your Own Functions . . . 78
3.12 Polynomials . . . 82
3.13 Limits . . . 83
3.14 Series . . . 84
3.15 Derivatives . . . 86
3.16 Integration . . . 88
3.17 Differential Equations . . . 91
3.18 Solution of Equations . . . 93

4 Graphics **95**
4.0.1 Plotting 2D graphs . . . 96
4.0.2 Palette . . . 100
4.0.3 Two-Dimensional Control-Panel . . . 101
4.0.4 Operations for Two-Dimensional Graphics . . . 104
4.0.5 Building Two-Dimensional Graphs Manually . . . 106
4.0.6 Appending a Graph to a Viewport Window Containing a Graph . . . 112
4.0.7 Plotting 3D Graphs . . . 113

4.0.8 Three-Dimensional Options . . . 115
4.0.9 Three-Dimensional Control-Panel . . . 116
4.0.10 Operations for Three-Dimensional Graphics . . . 120
4.0.11 Customization using .Xdefaults . . . 123

5 Using Types and Modes 125
5.1 The Basic Idea . . . 125
5.1.1 Domain Constructors . . . 126
5.2 Writing Types and Modes . . . 131
5.2.1 Types with No Arguments . . . 131
5.2.2 Types with One Argument . . . 132
5.2.3 Types with More Than One Argument . . . 133
5.2.4 Modes . . . 133
5.2.5 Abbreviations . . . 133
5.3 Declarations . . . 134
5.4 Records . . . 136
5.5 Unions . . . 139
5.5.1 Unions Without Selectors . . . 139
5.5.2 Unions With Selectors . . . 141
5.6 The "Any" Domain . . . 143
5.7 Conversion . . . 144
5.8 Subdomains Again . . . 146
5.9 Package Calling and Target Types . . . 149
5.10 Resolving Types . . . 151
5.11 Exposing Domains and Packages . . . 153
5.12 Commands for Snooping . . . 155

6 Using HyperDoc 159
6.1 Headings . . . 160
6.2 Key Definitions . . . 160
6.3 Scroll Bars . . . 160
6.4 Input Areas . . . 161
6.5 Radio Buttons and Toggles . . . 162
6.6 Search Strings . . . 162
6.6.1 Logical Searches . . . 162
6.7 Example Pages . . . 163
6.8 X Window Resources for HyperDoc . . . 163

7 Input Files and Output Styles 165
7.1 Input Files . . . 165
7.2 The .axiom.input File . . . 166
7.3 Common Features of Using Output Formats . . . 166
7.4 Monospace Two-Dimensional Mathematical Format . . . 167
7.5 TeX Format . . . 168
7.6 IBM Script Formula Format . . . 169
7.7 FORTRAN Format . . . 169

8 Axiom System Commands **173**
8.1 Introduction . . . 173
8.2)abbreviation . . . 174
8.3)boot . . . 175
8.4)cd . . . 176
8.5)close . . . 176
8.6)clear . . . 177
8.7)compile . . . 178
8.8)display . . . 179
8.9)edit . . . 181
8.10)fin . . . 181
8.11)frame . . . 181
8.12)hd . . . 183
8.13)help . . . 183
8.14)history . . . 184
8.15)library . . . 186
8.16)lisp . . . 186
8.17)ltrace . . . 187
8.18)pquit . . . 187
8.19)quit . . . 187
8.20)read . . . 188
8.21)set . . . 188
8.22)show . . . 189
8.23)spool . . . 190
8.24)synonym . . . 190
8.25)system . . . 191
8.26)trace . . . 192
8.27)undo . . . 195
8.28)what . . . 196
8.29 Makefile . . . 197

Bibliography **199**

Index **201**

Volume 2: Axiom Users Guide

1 The Axiom System by James H. Davenport 1
1.1 A little history . . . 1
1.2 Axiom's philosophy . . . 2
1.3 Axiom's typing scheme . . . 4
1.3.1 Aren't all these types confusing? . . . 6
1.4 Some AXIOM facilities . . . 8
1.4.1 How does one keep track of all this? . . . 11
1.5 Categories . . . 13
1.5.1 Using the `)display` command . . . 19

2 How does one program in the Axiom system by James H. Davenport 23
2.1 Introduction . . . 23
2.2 Programming concepts . . . 24
2.3 A first problem – Weighted Polynomials . . . 27
2.3.1 The problem definition . . . 27
2.3.2 The problem specification . . . 29
2.3.3 The problem implementation . . . 32
2.3.4 The `PolynomialRing` implementation . . . 33
2.3.5 Miscellaneous definitions . . . 35
2.4 A second problem – FourierSeries . . . 36
2.4.1 The problem definition . . . 36
2.4.2 The problem specification . . . 36
2.4.3 The `FourierComponent implementation` . . . 37
2.4.4 The `FourierSeries implementation` . . . 38

3 Axiom and Category Theory 41
3.1 Covariance and Contravariance . . . 41
3.2 Axiom Type Lattice . . . 42
3.3 Terms to Understand . . . 42
3.4 Category Definition . . . 43
3.5 Monoids and Groups . . . 44

4 Axiom Implementation Details 45
4.1 Makefile . . . 45

5 Writing Spad Code 47
5.1 The Description: label and the)describe command . . . 47

6 Writing test cases 51

A The Principles of Axiom 53

B The Axiom Conventions 55

C Example Code **57**
C.1 domain WP WeightedPolynomials 57
C.2 domain OWP OrdinaryWeightedPolynomials 59
C.3 domain WP2 WeightedPolynomials2 60
C.4 domain FCOMP FourierComponent 63
C.5 domain FSERIES FourierSeries 64

D The Makefile **67**

Bibliography **69**

Index **75**

Volume 3: Axiom Programmers Guide

1 A Language for Computational Algebra **1**
1.1 Introduction 1
1.2 Concepts 4

2 Details for Programmers **11**
2.1 Examining Internals 11
2.2 Makefile 13

Bibliography **15**

Volume 4: Axiom Developers Guide

0.1 MODLISP by James Davenport . . . 1
0.1.1 Introduction . . . 1
0.1.2 Interpretive Structure . . . 1
0.1.3 What is a MODE? . . . 3
0.1.4 Compilation . . . 4
0.1.5 Compilation for Arbitrary Domains . . . 5
0.1.6 Partial Declaration . . . 8
0.1.7 Status of the Project . . . 8
0.1.8 Acknowledgments . . . 8
0.1.9 Appendix A: Description of MODLISP Evaluator . . . 8
0.1.10 Explanation . . . 10
0.1.11 On Extensions for Partial Compilation . . . 11
0.1.12 On Extensions for Partial Declarations . . . 12
0.1.13 Appendix B: Sample Compilation by the MODLISP Evaluator . . . 13
0.2 Tedious Maintainer Tasks . . . 14
0.2.1 Maintaining the credits list . . . 14
0.3 What is the purpose of the HACKPI domain? . . . 14
0.4 How Axiom Builds . . . 15
0.4.1 The environment variables . . . 15
0.5 The runtime structure of Axiom . . . 17
0.5.1 The build step . . . 17
0.5.2 Where each output file is created . . . 21
0.6 How Axiom Works . . . 27
0.6.1 Input and Type Selection . . . 27
0.6.2 A simple integral . . . 31
0.6.3 A simple integral, expansion 1 interpreter . . . 32
0.6.4 A simple integral, expansion 2 integrate . . . 34
0.6.5 A simple integral, expansion 2 internalIntegrate . . . 37
0.6.6 A simple integral, expansion 3 univariate . . . 39
0.6.7 A simple integral, expansion 4 integrate . . . 41
0.6.8 A simple integral, expansion 5 monomialIntegrate . . . 42
0.6.9 A simple integral, expansion 6 HermiteIntegrate . . . 45
0.7 Tools . . . 48
0.7.1 svn . . . 48
0.7.2 git . . . 48
0.7.3 cvs . . . 48
0.8 Common Lisps . . . 51
0.8.1 GCL . . . 51
0.8.2 CCL . . . 52
0.8.3 CMU CL . . . 52
0.8.4 Franz Lisp . . . 52
0.8.5 Lucid Common Lisp . . . 52
0.8.6 Symbolics Common Lisp . . . 52
0.8.7 Golden Common Lisp . . . 52

0.8.8 VM/LISP 370 . . . 53
0.8.9 Maclisp . . . 53
0.9 Changing GCL versions . . . 53
0.10 Literate Programming . . . 55
0.10.1 Pamphlet files . . . 55
0.10.2 noweb . . . 56
0.11 Databases . . . 57
0.11.1 libcheck . . . 57
0.11.2 asq . . . 57
0.12 Axiom internal representations . . . 57
0.13 Spad to internal function calling . . . 60
0.13.1 getdatabse output . . . 60
0.14 axiom command . . . 68
0.15 help command documentation . . . 68
0.15.1 help documentation for algebra . . . 68
0.15.2 Adding help documentation in Makefile . . . 69
0.15.3 Using help documentation for regression testing . . . 70
0.15.4 help documentation as algebra test files . . . 70
0.16 debugsys . . . 70
0.16.1 debugging hyperdoc . . . 70
0.17 Understanding a compiled function . . . 71
0.18 The axiom.input startup file . . . 78
0.19 Where are Axiom symbols stored? . . . 79
0.20 Translating individual boot files to common lisp . . . 81
0.21 Directories . . . 81
0.21.1 The mnt/linux/bin directory . . . 82
0.21.2 The mnt/linux/doc directory . . . 83
0.21.3 The mnt/linux/algebra directory . . . 86
0.21.4 The mnt/linux/etc directory . . . 87
0.21.5 The mnt/linux/lib directory . . . 89
0.22 The)set command . . . 89
0.23 Special Output Formats . . . 90
0.24 Hand creating the hyperdoc binary . . . 90
0.25 Low Level Debugging Techniques . . . 90
0.25.1 Finding Anonymous Function Signatures . . . 90
0.25.2 The example bug . . . 94
0.25.3 Operating system level I/O trace (strace) . . . 109
0.26 How to make graphs in algebra books . . . 110
0.27 Adding or Editing pages in Hyperdoc . . . 111
0.28 Graphviz file creation . . . 112
0.29 Adding Algebra . . . 113
0.29.1 Adding algebra to the books . . . 113
0.29.2 Creating a stand-alone pamphlet file . . . 123
0.30 Makefile . . . 123

Bibliography **125**

Volume 5: Axiom Interpreter

1 Type Inference and Coercion **1**
1.1 Introduction . . . 1
1.2 Overview of the Abstract Datatype System . . . 2
1.2.1 Categories . . . 2
1.2.2 Domains . . . 3
1.2.3 Packages . . . 4
1.2.4 Modemaps . . . 5
1.2.5 Interpretation . . . 6
1.2.6 Modemap Selection . . . 6
1.2.7 Ambiguity . . . 8
1.2.8 Modes . . . 8
1.3 The Coerce Facility . . . 8
1.3.1 Coerce by Function . . . 9
1.3.2 Coerce by Mapping . . . 9
1.3.3 Coerce by Internal System Code . . . 9
1.3.4 Coercion of Algebraic Constants . . . 10
1.3.5 Retraction . . . 10
1.3.6 Coercion Query . . . 10
1.4 The Resolve Facility . . . 11
1.4.1 Resolve by Coercion Query . . . 11
1.4.2 Resolve by Rules . . . 11
1.4.3 Resolve by Type Destructuring . . . 12
1.5 An Example . . . 12
1.6 Acknowledgement . . . 12

2 The Interpreter **13**

3 The Fundamental Data Structures **15**
3.0.1 defvar $PatternVariableList . . . 15
3.0.2 defvar $FormalMapVariableList . . . 15
3.1 Frames and the Interpreter Frame Ring . . . 15
3.2)frame Command . . . 16
3.2.1 frame man page . . . 16
3.3 Data Structures . . . 18
3.4 Frame Access Macros . . . 19
3.4.1 defmacro frameName . . . 19
3.4.2 defmacro frameInteractive . . . 20
3.4.3 defmacro frameIOIndex . . . 20
3.4.4 defmacro frameHiFiAccess . . . 20
3.4.5 defmacro frameHistList . . . 20
3.4.6 defmacro frameHistListLen . . . 21
3.4.7 defmacro frameHistListAct . . . 21
3.4.8 defmacro frameHistRecord . . . 21

3.4.9 defmacro frameHistoryTable . . . 21
3.4.10 defmacro frameExposureData . . . 22
3.5 Functions to manipulate frames . . . 22
3.5.1 The top level frame command . . . 22
3.5.2 The top level frame command handler . . . 22
3.5.3 Initializing the Interpreter Frame Ring . . . 23
3.5.4 Create a new, empty Interpreter Frame . . . 24
3.5.5 Create a list of all of the frame names . . . 25
3.5.6 Display the frame name list message . . . 25
3.5.7 Collect the global variables into a Frame . . . 25
3.5.8 Update global variables from the Current Frame . . . 26
3.5.9 Replace the current frame and update from the globals . . . 27
3.5.10 Get Named Frame Environment (aka Interactive) . . . 27
3.5.11 Find a Frame in the Frame Ring by Name . . . 28
3.5.12 Change to the Named Interpreter Frame . . . 28
3.5.13 Move to the next Interpreter Frame in Ring . . . 28
3.5.14 Move to the previous Interpreter Frame in Ring . . . 29
3.5.15 Add a New Interpreter Frame . . . 29
3.5.16 Import items from another frame . . . 30
3.5.17 Close an Interpreter Frame . . . 33
3.6 Global variables associated with the frame . . . 34
3.6.1 defvar $interpreterFrameRing . . . 34
3.6.2 defvar $interpreterFrameName . . . 34
3.6.3 defvar $InteractiveFrame . . . 34
3.6.4 defvar $IOindex . . . 34
3.7 Interpreter Functions using Frames . . . 35

4 The Message Mechanism 37
4.0.1 defvar $msgAlist . . . 38
4.0.2 defvar $testingErrorPrefix . . . 38
4.0.3 defvar $msgdbPrims . . . 38
4.0.4 defvar $msgdbPunct . . . 38
4.0.5 defvar $msgdbNoBlanksBeforeGroup . . . 38
4.0.6 defvar $msgdbNoBlanksAfterGroup . . . 39
4.0.7 defun Say a message using a keyed lookup . . . 39
4.0.8 defun Handle msg formatting and print to file . . . 39
4.0.9 defun Break a message into words . . . 40
4.0.10 defun Write a msg into spadmsg.listing file . . . 40
4.0.11 defun sayMSG . . . 40

5 The History Mechanism 41
5.0.12 defvar $HiFiAccess . . . 41
5.0.13 defvar $HistList . . . 41
5.0.14 defvar $HistListLen . . . 41
5.0.15 defvar $HistListAct . . . 42
5.0.16 defvar $internalHistoryTable . . . 42

5.0.17 defvar $HistRecord . . . 42
5.0.18 defvar $historyFileType . . . 42

6 The undo mechanism 45
6.1 Data Structures . . . 45
6.2 Initial Undo Variables . . . 45
6.2.1 defvar $frameRecord . . . 45
6.2.2 defvar $previousBindings . . . 45
6.2.3 defvar $reportundo . . . 46
6.3 The undo functions . . . 46
6.3.1 defun undo . . . 46
6.3.2 defun undoSteps . . . 47
6.3.3 defun undoSingleStep . . . 48
6.3.4 defun undoLocalModemapHack . . . 49
6.3.5 Remove undo lines from history write . . . 50
6.3.6 defun reportUndo . . . 52
6.3.7 Undo previous n commands . . . 54

7 Tracing 55
7.1 The help text . . . 55
7.2 The trace global variables . . . 59
7.2.1 defvar $breakCondition . . . 59
7.2.2 defvar $constructors . . . 59
7.2.3 defvar $constructors . . . 60
7.2.4 defvar $countList . . . 60
7.2.5 defvar $depthAlist . . . 60
7.2.6 defvar $domains . . . 60
7.2.7 defvar $domainTraceNameAssoc . . . 60
7.2.8 defvar $doNotAddEmptyModeIfTrue . . . 60
7.2.9 defvar $embeddedFunctions . . . 61
7.2.10 defvar $fromSpadTrace . . . 61
7.2.11 defvar $lastUntraced . . . 61
7.2.12 defvar $letAssoc . . . 61
7.2.13 defvar $mapSubNameAlist . . . 61
7.2.14 defvar $mathTrace . . . 62
7.2.15 defvar $mathTraceList . . . 62
7.2.16 defvar $monitorArgs . . . 62
7.2.17 defvar $monitorCaller . . . 62
7.2.18 defvar $monitorDepth . . . 62
7.2.19 defvar $monitorFunDepth . . . 62
7.2.20 defvar $monitorName . . . 63
7.2.21 defvar $monitorPretty . . . 63
7.2.22 defvar $monitorValue . . . 63
7.2.23 defvar $optionAlist . . . 63
7.2.24 defvar $options . . . 63
7.2.25 defvar $OutputForm . . . 64

7.2.26 defvar $packages . . . 64
7.2.27 defvar $QuickLet . . . 64
7.2.28 defvar $reportSpadtrace . . . 64
7.2.29 defvar $spaceList . . . 64
7.2.30 defvar $streamCount . . . 64
7.2.31 defvar $timerList . . . 65
7.2.32 defvar $tracedMapSignatures . . . 65
7.2.33 defvar $traceDomains . . . 65
7.2.34 defvar $traceErrorStack . . . 65
7.2.35 defvar $TraceFlag . . . 65
7.2.36 defvar $traceletflag . . . 66
7.2.37 defvar $traceletFunctions . . . 66
7.2.38 defvar $traceNames . . . 66
7.2.39 defvar $traceNoisely . . . 66
7.2.40 defvar $traceOptionList . . . 66
7.2.41 defvar $tracedSpadModemap . . . 67
7.2.42 defvar $traceSize . . . 67
7.2.43 defvar $traceStream . . . 67
7.3 The trace initialization . . . 67
7.4 The trace functions . . . 67
7.4.1 defun The Top Level)trace Command Handler . . . 67
7.4.2 defun traceSpad2Cmd . . . 68
7.4.3 defun augmentTraceNames . . . 68
7.4.4 defun trace1 . . . 68
7.4.5 defun trace2 . . . 72
7.4.6 defun trace3 . . . 72
7.4.7 defun embededFunction . . . 77
7.4.8 defun embed2 . . . 77
7.4.9 defun flatBvList . . . 77
7.4.10 defun varp . . . 78
7.4.11 defun monitorX . . . 78
7.4.12 defun monitorXX . . . 78
7.4.13 defun monitorEvalBefore . . . 80
7.4.14 defun monitorEvalAfter . . . 81
7.4.15 defun monitorEvalTran . . . 81
7.4.16 defun monitorEvalTran1 . . . 81
7.4.17 defun hasSharpVar . . . 81
7.4.18 defun monitorGetValue . . . 82
7.4.19 defun traceReply . . . 82
7.4.20 defun /options . . . 84
7.4.21 defun Truncate list L at the point marked by TL. . . . 85
7.4.22 defun resetTimers . . . 85
7.4.23 defun resetSpacers . . . 85
7.4.24 defun resetCounters . . . 85
7.4.25 defun ptimers . . . 86
7.4.26 defun pspacers . . . 86

7.4.27 defun pcounters . . . 87
7.4.28 defun transOnlyOption . . . 87
7.4.29 defun stackTraceOptionError . . . 88
7.4.30 defun removeOption . . . 88
7.4.31 defun domainToGenvar . . . 88
7.4.32 defun subTypes . . . 89
7.4.33 defun isListOfIdentifiers . . . 89
7.4.34 defun isListOfIdentifiersOrStrings . . . 90
7.4.35 defun getPreviousMapSubNames . . . 90
7.4.36 defun lassocSub . . . 91
7.4.37 defun rassocSub . . . 91
7.4.38 defun isUncompiledMap . . . 91
7.4.39 defun isInterpOnlyMap . . . 92
7.4.40 defun isSubForRedundantMapName . . . 92
7.4.41 defun untraceMapSubNames . . . 92
7.4.42 defun funfind,LAM . . . 93
7.4.43 defmacro funfind . . . 93
7.4.44 defun isDomainOrPackage . . . 94
7.4.45 defun flattenOperationAlist . . . 94
7.4.46 defun letPrint . . . 95
7.4.47 defun Identifier beginning with a sharpsign-number? . . . 96
7.4.48 defun Identifier beginning with a sharpsign? . . . 96
7.4.49 defun letPrint2 . . . 96
7.4.50 defun letPrint3 . . . 98
7.4.51 defun hasPair . . . 99
7.4.52 defun shortenForPrinting . . . 99
7.4.53 defun getOption . . . 100
7.4.54 defun orderBySlotNumber . . . 100
7.4.55 defun spadReply . . . 100
7.4.56 defun remover . . . 101
7.4.57 defun stupidIsSpadFunction . . . 101
7.4.58 defun compileBoot . . . 101
7.4.59 defun getTraceOptions . . . 102
7.4.60 defun saveMapSig . . . 102
7.4.61 defun getMapSig . . . 103
7.4.62 defun getTraceOption,hn . . . 103
7.4.63 defun getTraceOption . . . 104
7.4.64 defun traceOptionError . . . 107
7.4.65 defun genDomainTraceName . . . 107
7.4.66 defun untrace . . . 108
7.4.67 defun /untrace-0 . . . 108
7.4.68 defun /untrace-1 . . . 109
7.4.69 defun /untrace-reduce . . . 109
7.4.70 defun /untrace-2 . . . 109
7.4.71 defun isGenvar . . . 111
7.4.72 defun transTraceItem . . . 111

7.4.73 defun removeTracedMapSigs . . . 112
7.4.74 defun coerceTraceArgs2E . . . 112
7.4.75 defun coerceSpadArgs2E . . . 113
7.4.76 defun coerceTraceFunValue2E . . . 114
7.4.77 defun coerceSpadFunValue2E . . . 115
7.4.78 defun getMapSubNames . . . 115
7.4.79 defun spadTrace,g . . . 116
7.4.80 defun spadTrace,isTraceable . . . 116
7.4.81 defun spadTrace . . . 116
7.4.82 defun getOperationAlistFromLisplib . . . 119
7.4.83 defun markUnique . . . 119
7.4.84 defun bpitrace . . . 120
7.4.85 defun traceDomainLocalOps . . . 120
7.4.86 defun untraceDomainLocalOps . . . 120
7.4.87 defun traceDomainConstructor . . . 120
7.4.88 defun untraceDomainConstructor,keepTraced? . . . 122
7.4.89 defun untraceDomainConstructor . . . 122
7.4.90 defun mapLetPrint . . . 123
7.4.91 defun getAliasIfTracedMapParameter . . . 123
7.4.92 defun getBpiNameIfTracedMap . . . 124
7.4.93 defun spadTraceAlias . . . 124
7.4.94 defun reportSpadTrace . . . 125
7.4.95 defun /tracereply . . . 125
7.4.96 defun spadUntrace . . . 126
7.4.97 defun prTraceNames,fn . . . 128
7.4.98 defun prTraceNames . . . 128
7.4.99 defun addTraceItem . . . 129
7.4.100 defun ?t . . . 129
7.4.101 defun Handle traced function entry . . . 130
7.4.102 defun Print the arguments to a traced function . . . 131
7.4.103 defun monitorPrintArg . . . 132
7.4.104 defun monitorPrint . . . 132
7.4.105 defun monitorPrintRest . . . 133
7.4.106 defun prinmathor0 . . . 133
7.4.107 defun Handle traced function exit . . . 133
7.4.108 defun monitorPrintValue . . . 134
7.4.109 defun limitedPrint1 . . . 135
7.4.110 defun smallEnough . . . 135
7.4.111 defun How big is an object? . . . 135
7.4.112 defun tracelet . . . 136
7.4.113 defun breaklet . . . 136
7.4.114 defun break . . . 137

8 Exposure groups **139**
8.1 Functions to manipulate exposure . . . 139
8.1.1 Expose a group . . . 139
8.1.2 The top level set expose command handler . . . 140
8.1.3 The top level set expose add command handler . . . 141
8.1.4 The top level set expose add constructor handler . . . 142
8.1.5 The top level set expose drop handler . . . 143
8.1.6 The top level set expose drop group handler . . . 144
8.1.7 The top level set expose drop constructor handler . . . 145
8.1.8 Display exposed groups . . . 146
8.1.9 Display exposed constructors . . . 146
8.1.10 Display hidden constructors . . . 147
8.2 Exposure Data Structures . . . 147
8.2.1 defvar $localExposureData . . . 147
8.2.2 defvar $localExposureDataDefault . . . 148
8.2.3 defvar $globalExposureGroupAlist . . . 148

9 The global variables **173**
9.0.4 Credits . . . 173
9.0.5 defvar creditlist . . . 173
9.0.6 defvar $current-directory . . . 176
9.0.7 defvar $directory-list . . . 176
9.0.8 defvar $InitialModemapFrame . . . 176
9.0.9 defvar $library-directory-list . . . 177
9.0.10 defvar $msgDatabaseName . . . 177
9.0.11 defvar $openServerIfTrue . . . 177
9.0.12 defvar $relative-directory-list . . . 178
9.0.13 defvar $relative-library-directory-list . . . 178
9.0.14 defvar $spadroot . . . 178
9.0.15 defvar $SpadServer . . . 179
9.0.16 defvar $SpadServerName . . . 179

10 Starting Axiom **181**
10.1 An Overview of a Simple Input . . . 183
10.2 Parsing the input . . . 185
10.2.1 Creating a Delay – incString . . . 185
10.2.2 Creating a Delay – next . . . 186
10.2.3 Creating a Delay – ncloopParse . . . 187
10.2.4 Evaluating a Delay – intloopProcess . . . 187

11 Axiom Details **275**
11.1 Variables Used . . . 275
11.2 Data Structures . . . 275
11.3 Functions . . . 275
11.3.1 Set the restart hook . . . 275
11.3.2 restart function (The restart function) . . . 276

11.3.3 defvar localVars . . . 278
11.3.4 defun Non-interactive restarts . . . 278
11.3.5 defun The startup banner messages . . . 279
11.3.6 defun Make a vector of filler characters . . . 279
11.3.7 defvar $PrintCompilerMessageIfTrue . . . 280
11.3.8 Starts the interpreter but do not read in profiles . . . 280
11.3.9 defvar $quitTag . . . 280
11.3.10 defun runspad . . . 280
11.3.11 defun Reset the stack limits . . . 281

12 Handling Terminal Input 283
12.1 Streams . . . 283
12.1.1 defvar curinstream . . . 283
12.1.2 defvar curoutstream . . . 283
12.1.3 defvar errorinstream . . . 283
12.1.4 defvar erroroutstream . . . 284
12.1.5 defvar *eof* . . . 284
12.1.6 defvar *whitespace* . . . 284
12.1.7 defvar $InteractiveMode . . . 284
12.1.8 defvar $env . . . 284
12.1.9 defvar $e . . . 285
12.1.10 defvar $boot . . . 285
12.1.11 $newspad . . . 285
12.1.12 defvar $newspad . . . 285
12.1.13 Top-level read-parse-eval-print loop . . . 285
12.1.14 defun ncIntLoop . . . 286
12.1.15 defvar $intTopLevel . . . 286
12.1.16 defvar $intRestart . . . 287
12.1.17 defun intloop . . . 287
12.1.18 defvar $ncMsgList . . . 287
12.1.19 defun SpadInterpretStream . . . 288
12.1.20 defun GCL cmpnote function . . . 288
12.1.21 defvar $newcompErrorCount . . . 288
12.1.22 defvar $nopos . . . 288
12.2 The Read-Eval-Print Loop . . . 289
12.2.1 defun intloopReadConsole . . . 289
12.3 Helper Functions . . . 291
12.3.1 Get the value of an evironment variable . . . 291
12.3.2 defvar $intCoerceFailure . . . 292
12.3.3 defvar $intSpadReader . . . 292
12.3.4 defun InterpExecuteSpadSystemCommand . . . 292
12.3.5 defun ExecuteInterpSystemCommand . . . 292
12.3.6 defun substring . . . 293
12.3.7 defun Handle Synonyms . . . 293
12.3.8 defun Synonym File Reader . . . 293
12.3.9 defun init-memory-config . . . 294

12.3.10 Set spadroot to be the AXIOM shell variable . . . 295
12.3.11 Does the string start with this prefix? . . . 295
12.3.12 defun Interpret a line of lisp code . . . 296
12.3.13 Get the current directory . . . 296
12.3.14 Prepend the absolute path to a filename . . . 296
12.3.15 Make the initial modemap frame . . . 296
12.3.16 defun ncloopEscaped . . . 297
12.3.17 defun intloopProcessString . . . 297
12.3.18 defun ncloopParse . . . 297
12.3.19 defun next . . . 298
12.3.20 defun next1 . . . 298
12.3.21 defun incString . . . 298
12.3.22 Call the garbage collector . . . 299
12.3.23 defun reroot . . . 299
12.3.24 defvar $current-directory . . . 301
12.3.25 defun setCurrentLine . . . 301
12.3.26 Show the Axiom prompt . . . 301
12.3.27 defvar $frameAlist . . . 302
12.3.28 defvar $frameNumber . . . 302
12.3.29 defvar $currentFrameNum . . . 302
12.3.30 defvar $EndServerSession . . . 302
12.3.31 defvar $NeedToSignalSessionManager . . . 303
12.3.32 defvar $sockBufferLength . . . 303
12.3.33 READ-LINE in an Axiom server system . . . 303
12.3.34 defun protectedEVAL . . . 305
12.3.35 defvar $QuietCommand . . . 306
12.3.36 defun executeQuietCommand . . . 306
12.3.37 defun parseAndInterpret . . . 306
12.3.38 defun parseFromString . . . 307
12.3.39 defvar $interpOnly . . . 307
12.3.40 defvar $minivectorNames . . . 307
12.3.41 defvar $domPvar . . . 308
12.3.42 defvar $compilingMap . . . 308
12.3.43 defvar $instantRecord . . . 308
12.3.44 defun processInteractive . . . 308
12.3.45 defvar $ProcessInteractiveValue . . . 310
12.3.46 defvar $HTCompanionWindowID . . . 310
12.3.47 defun processInteractive1 . . . 311
12.3.48 defun interpretTopLevel . . . 311
12.3.49 defvar $genValue . . . 312
12.3.50 defun Type analyzes and evaluates expression x, returns object . . . 312
12.3.51 defun Dispatcher for the type analysis routines . . . 312
12.3.52 defvar $ThrowAwayMode . . . 313
12.3.53 defun interpret2 . . . 313
12.3.54 defvar $runTestFlag . . . 314
12.3.55 defvar $mkTestFlag . . . 314

12.3.56 defun Result Output Printing . . . 315
12.3.57 defun printStatisticsSummary . . . 316
12.3.58 defun printStorage . . . 316
12.3.59 defun printTypeAndTime . . . 317
12.3.60 defun printAsTeX . . . 318
12.3.61 defun sameUnionBranch . . . 318
12.3.62 defun msgText . . . 319
12.3.63 defun Right-justify the Type output . . . 319
12.3.64 defun Destructively fix quotes in strings . . . 319
12.3.65 Include a file into the stream . . . 320
12.3.66 defun intloopInclude0 . . . 320
12.3.67 defun intloopProcess . . . 320
12.3.68 defun intloopSpadProcess . . . 321
12.3.69 defun intloopSpadProcess,interp . . . 322
12.3.70 defun phParse . . . 323
12.3.71 defun phIntReportMsgs . . . 323
12.3.72 defun phInterpret . . . 324
12.3.73 defun intInterpretPform . . . 324
12.3.74 defun zeroOneTran . . . 324
12.3.75 defun ncConversationPhase . . . 324
12.3.76 defun ncConversationPhase,wrapup . . . 325
12.3.77 defun ncError . . . 325
12.3.78 defun intloopEchoParse . . . 325
12.3.79 defun ncloopPrintLines . . . 326
12.3.80 defun mkLineList . . . 326
12.3.81 defun nonBlank . . . 327
12.3.82 defun ncloopDQlines . . . 327
12.3.83 defun poGlobalLinePosn . . . 328
12.3.84 defun streamChop . . . 328
12.3.85 defun ncloopInclude0 . . . 329
12.3.86 defun incStream . . . 329
12.3.87 defun incRenumber . . . 329
12.3.88 defun incZip . . . 330
12.3.89 defun incZip1 . . . 330
12.3.90 defun incIgen . . . 330
12.3.91 defun incIgen1 . . . 331
12.3.92 defun incRenumberLine . . . 331
12.3.93 defun incRenumberItem . . . 331
12.3.94 defun incHandleMessage . . . 331
12.3.95 defun incLude . . . 332
12.3.96 defmacro Rest . . . 332
12.3.97 defvar Top . . . 333
12.3.98 defvar IfSkipToEnd . . . 333
12.3.99 defvar IfKeepPart . . . 333
12.3.100 defvar IfSkipPart . . . 333
12.3.101 defvar ElseifSkipToEnd . . . 333

12.3.102defvar ElseifKeepPart . . . 333
12.3.103defvar ElseifSkipPart . . . 334
12.3.104defvar ElseSkipToEnd . . . 334
12.3.105defvar ElseKeepPart . . . 334
12.3.106defun Top? . . . 334
12.3.107defun If? . . . 334
12.3.108defun Elseif? . . . 335
12.3.109defun Else? . . . 335
12.3.110defun SkipEnd? . . . 335
12.3.111defun KeepPart? . . . 335
12.3.112defun SkipPart? . . . 336
12.3.113defun Skipping? . . . 336
12.3.114defun incLude1 . . . 336
12.3.115defun xlPrematureEOF . . . 340
12.3.116defun xlMsg . . . 340
12.3.117defun xlOK . . . 341
12.3.118defun xlOK1 . . . 341
12.3.119defun incAppend . . . 341
12.3.120defun incAppend1 . . . 341
12.3.121defun incLine . . . 342
12.3.122defun incLine1 . . . 342
12.3.123defun inclmsgPrematureEOF . . . 342
12.3.124defun theorigin . . . 343
12.3.125defun porigin . . . 343
12.3.126defun ifCond . . . 343
12.3.127defun xlSkip . . . 343
12.3.128defun xlSay . . . 344
12.3.129defun inclmsgSay . . . 344
12.3.130defun theid . . . 344
12.3.131defun xlNoSuchFile . . . 344
12.3.132defun inclmsgNoSuchFile . . . 345
12.3.133defun thefname . . . 345
12.3.134defun pfname . . . 345
12.3.135defun xlCannotRead . . . 345
12.3.136defun inclmsgCannotRead . . . 345
12.3.137defun xlFileCycle . . . 346
12.3.138defun inclmsgFileCycle . . . 346
12.3.139defun xlConActive . . . 347
12.3.140defun inclmsgConActive . . . 347
12.3.141defun xlConStill . . . 347
12.3.142defun inclmsgConStill . . . 348
12.3.143defun xlConsole . . . 348
12.3.144defun inclmsgConsole . . . 348
12.3.145defun xlSkippingFin . . . 348
12.3.146defun inclmsgFinSkipped . . . 349
12.3.147defun xlPrematureFin . . . 349

12.3.148 defun inclmsgPrematureFin . . . 349
12.3.149 defun assertCond . . . 350
12.3.150 defun xlIfSyntax . . . 350
12.3.151 defun inclmsgIfSyntax . . . 350
12.3.152 defun xlIfBug . . . 351
12.3.153 defun inclmsgIfBug . . . 351
12.3.154 defun xlCmdBug . . . 351
12.3.155 defun inclmsgCmdBug . . . 351
12.3.156 defvar incCommands . . . 352
12.3.157 defvar $pfMacros . . . 352
12.3.158 defun incClassify . . . 352
12.3.159 defun incCommand? . . . 353
12.3.160 defun incPrefix? . . . 354
12.3.161 defun incCommandTail . . . 354
12.3.162 defun incDrop . . . 355
12.3.163 defun inclFname . . . 355
12.3.164 defun incFileInput . . . 355
12.3.165 defun incConsoleInput . . . 355
12.3.166 defun incNConsoles . . . 356
12.3.167 defun incActive? . . . 356
12.3.168 defun incRgen . . . 356
12.3.169 defun Delay . . . 356
12.3.170 defvar StreamNil . . . 357
12.3.171 defun incRgen1 . . . 357

13 The Token Scanner **359**
13.0.172 defvar scanKeyWords . . . 359
13.0.173 defvar infgeneric . . . 361
13.0.174 defun lineoftoks . . . 362
13.0.175 defun nextline . . . 363
13.0.176 defun scanIgnoreLine . . . 364
13.0.177 defun constoken . . . 364
13.0.178 defun scanToken . . . 365
13.0.179 defun lfid . . . 366
13.0.180 defun Is it a ++ comment? . . . 366
13.0.181 defun scanComment . . . 366
13.0.182 defun lfcomment . . . 367
13.0.183 defun Is it a – comment? . . . 367
13.0.184 defun scanNegComment . . . 367
13.0.185 defun lfnegcomment . . . 368
13.0.186 defun punctuation? . . . 368
13.0.187 defun scanPunct . . . 368
13.0.188 defun subMatch . . . 369
13.0.189 defun substringMatch . . . 369
13.0.190 defun scanKeyTr . . . 370
13.0.191 defun keyword . . . 370

13.0.192 defun keyword? . . . 371
13.0.193 defun scanPossFloat . . . 371
13.0.194 defun digit? . . . 371
13.0.195 defun lfkey . . . 371
13.0.196 defun spleI . . . 372
13.0.197 defun spleI1 . . . 372
13.0.198 defun scanEsc . . . 373
13.0.199 defvar scanCloser . . . 374
13.0.200 defun scanCloser? . . . 375
13.0.201 defun scanWord . . . 375
13.0.202 defun scanExponent . . . 375
13.0.203 defun lffloat . . . 376
13.0.204 defmacro idChar? . . . 377
13.0.205 defun scanW . . . 377
13.0.206 defun posend . . . 378
13.0.207 defun scanSpace . . . 378
13.0.208 defun lfspaces . . . 378
13.0.209 defun scanString . . . 379
13.0.210 defun lfstring . . . 379
13.0.211 defun scanS . . . 379
13.0.212 defun scanTransform . . . 380
13.0.213 defun scanNumber . . . 380
13.0.214 defun rdigit? . . . 381
13.0.215 defun lfinteger . . . 382
13.0.216 defun lfrinteger . . . 382
13.0.217 defun scanCheckRadix . . . 382
13.0.218 defun scanEscape . . . 383
13.0.219 defun scanError . . . 383
13.0.220 defun lferror . . . 384
13.0.221 defvar scanKeyTable . . . 384
13.0.222 defun scanKeyTableCons . . . 384
13.0.223 defvar scanDict . . . 385
13.0.224 defun scanDictCons . . . 385
13.0.225 defun scanInsert . . . 386
13.0.226 defvar scanPun . . . 387
13.0.227 defun scanPunCons . . . 387

14 Input Stream Parser **389**
14.0.228 defun Input Stream Parser . . . 389
14.0.229 defun npItem . . . 390
14.0.230 defun npItem1 . . . 390
14.0.231 defun npFirstTok . . . 391
14.0.232 defun Push one item onto $stack . . . 391
14.0.233 defun Pop one item off $stack . . . 391
14.0.234 defun Pop the second item off $stack . . . 392
14.0.235 defun Pop the third item off $stack . . . 392

14.0.236defun npQualDef . . . 392
14.0.237defun Advance over a keyword . . . 392
14.0.238defun Advance the input stream . . . 393
14.0.239defun npComma . . . 393
14.0.240defun npTuple . . . 393
14.0.241defun npCommaBackSet . . . 394
14.0.242defun npQualifiedDefinition . . . 394
14.0.243defun npQualified . . . 394
14.0.244defun npDefinitionOrStatement . . . 395
14.0.245defun npBackTrack . . . 395
14.0.246defun npGives . . . 395
14.0.247defun npLambda . . . 396
14.0.248defun npType . . . 396
14.0.249defun npMatch . . . 397
14.0.250defun npSuch . . . 397
14.0.251defun npWith . . . 397
14.0.252defun npCompMissing . . . 398
14.0.253defun npMissing . . . 398
14.0.254defun npRestore . . . 398
14.0.255defun Peek for keyword s, no advance of token stream . . . 399
14.0.256defun npCategoryL . . . 399
14.0.257defun npCategory . . . 399
14.0.258defun npSCategory . . . 400
14.0.259defun npSignature . . . 400
14.0.260defun npSigItemlist . . . 401
14.0.261defun npListing . . . 401
14.0.262defun Always produces a list, fn is applied to it . . . 401
14.0.263defun npSigItem . . . 402
14.0.264defun npTypeVariable . . . 402
14.0.265defun npSignatureDefinee . . . 403
14.0.266defun npTypeVariablelist . . . 403
14.0.267defun npSigDecl . . . 403
14.0.268defun npPrimary . . . 403
14.0.269defun npPrimary2 . . . 404
14.0.270defun npADD . . . 404
14.0.271defun npAdd . . . 405
14.0.272defun npAtom2 . . . 405
14.0.273defun npInfixOperator . . . 406
14.0.274defun npInfixOp . . . 406
14.0.275defun npPrefixColon . . . 407
14.0.276defun npApplication . . . 407
14.0.277defun npDotted . . . 408
14.0.278defun npAnyNo . . . 408
14.0.279defun npSelector . . . 408
14.0.280defun npApplication2 . . . 409
14.0.281defun npPrimary1 . . . 409

14.0.282 defun npMacro . . . 410
14.0.283 defun npMdef . . . 410
14.0.284 defun npMDEF . . . 410
14.0.285 defun npMDEFinition . . . 411
14.0.286 defun npFix . . . 411
14.0.287 defun npLet . . . 411
14.0.288 defun npLetQualified . . . 412
14.0.289 defun npDefinition . . . 412
14.0.290 defun npDefinitionItem . . . 412
14.0.291 defun npTyping . . . 413
14.0.292 defun npDefaultItemlist . . . 413
14.0.293 defun npSDefaultItem . . . 414
14.0.294 defun npDefaultItem . . . 414
14.0.295 defun npDefaultDecl . . . 414
14.0.296 defun npStatement . . . 415
14.0.297 defun npExport . . . 415
14.0.298 defun npLocalItemlist . . . 416
14.0.299 defun npSLocalItem . . . 416
14.0.300 defun npLocalItem . . . 417
14.0.301 defun npLocalDecl . . . 417
14.0.302 defun npLocal . . . 417
14.0.303 defun npFree . . . 418
14.0.304 defun npInline . . . 418
14.0.305 defun npIterate . . . 418
14.0.306 defun npBreak . . . 419
14.0.307 defun npLoop . . . 419
14.0.308 defun npIterators . . . 419
14.0.309 defun npIterator . . . 420
14.0.310 defun npSuchThat . . . 420
14.0.311 defun Apply argument 0 or more times . . . 421
14.0.312 defun npWhile . . . 421
14.0.313 defun npForIn . . . 421
14.0.314 defun npReturn . . . 422
14.0.315 defun npVoid . . . 422
14.0.316 defun npExpress . . . 423
14.0.317 defun npExpress1 . . . 423
14.0.318 defun npConditionalStatement . . . 423
14.0.319 defun npImport . . . 424
14.0.320 defun npQualTypelist . . . 424
14.0.321 defun npSQualTypelist . . . 424
14.0.322 defun npQualType . . . 425
14.0.323 defun npAndOr . . . 425
14.0.324 defun npEncAp . . . 425
14.0.325 defun npEncl . . . 426
14.0.326 defun npAtom1 . . . 426
14.0.327 defun npPDefinition . . . 426

14.0.328 defun npDollar . . . 427
14.0.329 defun npConstTok . . . 427
14.0.330 defun npBDefinition . . . 428
14.0.331 defun npBracketed . . . 428
14.0.332 defun npParened . . . 428
14.0.333 defun npBracked . . . 429
14.0.334 defun npBraced . . . 429
14.0.335 defun npAngleBared . . . 429
14.0.336 defun npDefn . . . 429
14.0.337 defun npDef . . . 430
14.0.338 defun npBPileDefinition . . . 430
14.0.339 defun npPileBracketed . . . 431
14.0.340 defun npPileDefinitionlist . . . 431
14.0.341 defun npListAndRecover . . . 432
14.0.342 defun npRecoverTrap . . . 433
14.0.343 defun npMoveTo . . . 433
14.0.344 defun syIgnoredFromTo . . . 434
14.0.345 defun syGeneralErrorHere . . . 434
14.0.346 defun sySpecificErrorHere . . . 434
14.0.347 defun sySpecificErrorAtToken . . . 435
14.0.348 defun npDefinitionlist . . . 435
14.0.349 defun npSemiListing . . . 435
14.0.350 defun npSemiBackSet . . . 435
14.0.351 defun npRule . . . 436
14.0.352 defun npSingleRule . . . 436
14.0.353 defun npDefTail . . . 436
14.0.354 defun npDefaultValue . . . 437
14.0.355 defun npWConditional . . . 437
14.0.356 defun npConditional . . . 437
14.0.357 defun npElse . . . 438
14.0.358 defun npBacksetElse . . . 438
14.0.359 defun npLogical . . . 439
14.0.360 defun npDisjand . . . 439
14.0.361 defun npDiscrim . . . 439
14.0.362 defun npQuiver . . . 439
14.0.363 defun npRelation . . . 440
14.0.364 defun npSynthetic . . . 440
14.0.365 defun npBy . . . 441
14.0.366 defun . . . 441
14.0.367 defun npSegment . . . 441
14.0.368 defun npArith . . . 442
14.0.369 defun npSum . . . 442
14.0.370 defun npTerm . . . 442
14.0.371 defun npRemainder . . . 443
14.0.372 defun npProduct . . . 443
14.0.373 defun npPower . . . 443

14.0.374 defun npAmpersandFrom . . . 443
14.0.375 defun npFromdom . . . 444
14.0.376 defun npFromdom1 . . . 444
14.0.377 defun npAmpersand . . . 444
14.0.378 defun npName . . . 445
14.0.379 defvar $npTokToNames . . . 445
14.0.380 defun npId . . . 445
14.0.381 defun npSymbolVariable . . . 446
14.0.382 defun npRightAssoc . . . 446
14.0.383 defun p o p o p o p = (((p o p) o p) o p) . . . 447
14.0.384 defun npInfGeneric . . . 448
14.0.385 defun npDDInfKey . . . 448
14.0.386 defun npInfKey . . . 449
14.0.387 defun npPushId . . . 449
14.0.388 defvar npPParg . . . 449
14.0.389 defun npPP . . . 450
14.0.390 defun npPPff . . . 450
14.0.391 defun npPPg . . . 450
14.0.392 defun npPPf . . . 451
14.0.393 defun npEnclosed . . . 451
14.0.394 defun npState . . . 452
14.0.395 defun npTrap . . . 452
14.0.396 defun npTrapForm . . . 452
14.0.397 defun npVariable . . . 453
14.0.398 defun npVariablelist . . . 453
14.0.399 defun npVariableName . . . 453
14.0.400 defun npDecl . . . 454
14.0.401 defun npParenthesized . . . 454
14.0.402 defun npParenthesize . . . 454
14.0.403 defun npMissingMate . . . 455
14.0.404 defun npExit . . . 455
14.0.405 defun npPileExit . . . 455
14.0.406 defun npAssign . . . 456
14.0.407 defun npAssignment . . . 456
14.0.408 defun npAssignVariable . . . 456
14.0.409 defun npColon . . . 457
14.0.410 defun npTagged . . . 457
14.0.411 defun npTypedForm1 . . . 457
14.0.412 defun npTypified . . . 458
14.0.413 defun npTypeStyle . . . 458
14.0.414 defun npPretend . . . 458
14.0.415 defun npColonQuery . . . 458
14.0.416 defun npCoerceTo . . . 459
14.0.417 defun npTypedForm . . . 459
14.0.418 defun npRestrict . . . 459
14.0.419 defun npListofFun . . . 459

14.1 Functions on interpreter objects . . . 460
14.1.1 defmacro mkObj . . . 460
14.1.2 defmacro mkObjWrap . . . 461
14.1.3 defmacro mkObjCode . . . 461
14.1.4 defmacro objSetVal . . . 461
14.1.5 defmacro objSetMode . . . 461
14.1.6 defmacro objVal . . . 462
14.1.7 defmacro objValUnwrap . . . 462
14.1.8 defmacro objMode . . . 462
14.1.9 defun objEnv . . . 462
14.1.10 defmacro objCodeVal . . . 462
14.1.11 defmacro objCodeMode . . . 463
14.2 Macro handling . . . 463
14.2.1 defun phMacro . . . 463
14.2.2 defun macroExpanded . . . 463
14.2.3 defun macExpand . . . 464
14.2.4 defun macApplication . . . 464
14.2.5 defun mac0MLambdaApply . . . 465
14.2.6 defun mac0ExpandBody . . . 466
14.2.7 defun mac0InfiniteExpansion . . . 466
14.2.8 defun mac0InfiniteExpansion,name . . . 467
14.2.9 defun mac0GetName . . . 467
14.2.10 defun macId . . . 468
14.2.11 defun mac0Get . . . 469
14.2.12 defun macWhere . . . 469
14.2.13 defun macWhere,mac . . . 469
14.2.14 defun macLambda . . . 469
14.2.15 defun macLambda,mac . . . 470
14.2.16 defun Add appropriate definition the a Macro pform . . . 470
14.2.17 defun Add a macro to the global pfMacros list . . . 471
14.2.18 defun macSubstituteOuter . . . 471
14.2.19 defun mac0SubstituteOuter . . . 471
14.2.20 defun macLambdaParameterHandling . . . 472
14.2.21 defun macSubstituteId . . . 473

15 Pftrees 475
15.1 Abstract Syntax Trees Overview . . . 475
15.2 Structure handlers . . . 477
15.2.1 defun pfGlobalLinePosn . . . 477
15.2.2 defun pfCharPosn . . . 477
15.2.3 defun pfLinePosn . . . 477
15.2.4 defun pfFileName . . . 477
15.2.5 defun pfCopyWithPos . . . 478
15.2.6 defun pfMapParts . . . 478
15.2.7 defun pf0ApplicationArgs . . . 479
15.2.8 defun pf0FlattenSyntacticTuple . . . 479

15.2.9 defun pfSourcePosition . . . 479
15.2.10 defun Convert a Sequence node to a list . . . 480
15.2.11 defun pfSpread . . . 480
15.2.12 defun Deconstruct nodes to lists . . . 480
15.2.13 defun pfCheckMacroOut . . . 481
15.2.14 defun pfCheckArg . . . 482
15.2.15 defun pfCheckId . . . 482
15.2.16 defun pfFlattenApp . . . 483
15.2.17 defun pfCollect1? . . . 483
15.2.18 defun pfCollectVariable1 . . . 483
15.2.19 defun pfPushMacroBody . . . 484
15.2.20 defun pfSourceStok . . . 484
15.2.21 defun pfTransformArg . . . 484
15.2.22 defun pfTaggedToTyped1 . . . 485
15.2.23 defun pfSuch . . . 485
15.3 Special Nodes . . . 485
15.3.1 defun Create a Listof node . . . 485
15.3.2 defun pfNothing . . . 486
15.3.3 defun Is this a Nothing node? . . . 486
15.4 Leaves . . . 486
15.4.1 defun Create a Document node . . . 486
15.4.2 defun Construct an Id node . . . 486
15.4.3 defun Is this an Id node? . . . 487
15.4.4 defun Construct an Id leaf node . . . 487
15.4.5 defun Return the Id part . . . 487
15.4.6 defun Construct a Leaf node . . . 487
15.4.7 defun Is this a leaf node? . . . 488
15.4.8 defun Return the token position of a leaf node . . . 488
15.4.9 defun Return the Leaf Token . . . 488
15.4.10 defun Is this a Literal node? . . . 488
15.4.11 defun Create a LiteralClass node . . . 489
15.4.12 defun Return the LiteralString . . . 489
15.4.13 defun Return the parts of a tree node . . . 489
15.4.14 defun Return the argument unchanged . . . 489
15.4.15 defun pfPushBody . . . 489
15.4.16 defun An S-expression which people can read. . . . 490
15.4.17 defun Create a human readable S-expression . . . 490
15.4.18 defun Construct a Symbol or Expression node . . . 491
15.4.19 defun Construct a Symbol leaf node . . . 491
15.4.20 defun Is this a Symbol node? . . . 491
15.4.21 defun Return the Symbol part . . . 492
15.5 Trees . . . 492
15.5.1 defun Construct a tree node . . . 492
15.5.2 defun Construct an Add node . . . 492
15.5.3 defun Construct an And node . . . 492
15.5.4 defun pfAttribute . . . 493

15.5.5 defun Return an Application node . . . 493
15.5.6 defun Return the Arg part of an Application node . . . 493
15.5.7 defun Return the Op part of an Application node . . . 493
15.5.8 defun Is this an And node? . . . 493
15.5.9 defun Return the Left part of an And node . . . 494
15.5.10 defun Return the Right part of an And node . . . 494
15.5.11 defun Flatten a list of lists . . . 494
15.5.12 defun Is this an Application node? . . . 494
15.5.13 defun Create an Assign node . . . 494
15.5.14 defun Is this an Assign node? . . . 495
15.5.15 defun Return the parts of an LhsItem of an Assign node . . . 495
15.5.16 defun Return the LhsItem of an Assign node . . . 495
15.5.17 defun Return the RHS of an Assign node . . . 495
15.5.18 defun Construct an application node for a brace . . . 496
15.5.19 defun Construct an Application node for brace-bars . . . 496
15.5.20 defun Construct an Application node for a bracket . . . 496
15.5.21 defun Construct an Application node for bracket-bars . . . 496
15.5.22 defun Create a Break node . . . 497
15.5.23 defun Is this a Break node? . . . 497
15.5.24 defun Return the From part of a Break node . . . 497
15.5.25 defun Construct a Coerceto node . . . 497
15.5.26 defun Is this a CoerceTo node? . . . 497
15.5.27 defun Return the Expression part of a CoerceTo node . . . 498
15.5.28 defun Return the Type part of a CoerceTo node . . . 498
15.5.29 defun Return the Body of a Collect node . . . 498
15.5.30 defun Return the Iterators of a Collect node . . . 498
15.5.31 defun Create a Collect node . . . 499
15.5.32 defun Is this a Collect node? . . . 499
15.5.33 defun pfDefinition . . . 499
15.5.34 defun Return the Lhs of a Definition node . . . 499
15.5.35 defun Return the Rhs of a Definition node . . . 499
15.5.36 defun Is this a Definition node? . . . 500
15.5.37 defun Return the parts of a Definition node . . . 500
15.5.38 defun Create a Do node . . . 500
15.5.39 defun Is this a Do node? . . . 500
15.5.40 defun Return the Body of a Do node . . . 501
15.5.41 defun Construct a Sequence node . . . 501
15.5.42 defun Construct an Exit node . . . 501
15.5.43 defun Is this an Exit node? . . . 501
15.5.44 defun Return the Cond part of an Exit . . . 502
15.5.45 defun Return the Expression part of an Exit . . . 502
15.5.46 defun Create an Export node . . . 502
15.5.47 defun Construct an Expression leaf node . . . 502
15.5.48 defun pfFirst . . . 502
15.5.49 defun Create an Application Fix node . . . 503
15.5.50 defun Create a Free node . . . 503

15.5.51 defun Is this a Free node? . . . 503
15.5.52 defun Return the parts of the Items of a Free node . . . 503
15.5.53 defun Return the Items of a Free node . . . 504
15.5.54 defun Construct a Forin node . . . 504
15.5.55 defun Is this a ForIn node? . . . 504
15.5.56 defun Return all the parts of the LHS of a ForIn node . . . 504
15.5.57 defun Return the LHS part of a ForIn node . . . 504
15.5.58 defun Return the Whole part of a ForIn node . . . 505
15.5.59 defun pfFromDom . . . 505
15.5.60 defun Construct a Fromdom node . . . 505
15.5.61 defun Is this a Fromdom mode? . . . 505
15.5.62 defun Return the What part of a Fromdom node . . . 506
15.5.63 defun Return the Domain part of a Fromdom node . . . 506
15.5.64 defun Construct a Hide node . . . 506
15.5.65 defun pfIf . . . 506
15.5.66 defun Is this an If node? . . . 507
15.5.67 defun Return the Cond part of an If . . . 507
15.5.68 defun Return the Then part of an If . . . 507
15.5.69 defun pfIfThenOnly . . . 507
15.5.70 defun Return the Else part of an If . . . 507
15.5.71 defun Construct an Import node . . . 508
15.5.72 defun Construct an Iterate node . . . 508
15.5.73 defun Is this an Iterate node? . . . 508
15.5.74 defun Handle an infix application . . . 508
15.5.75 defun Create an Inline node . . . 509
15.5.76 defun pfLam . . . 509
15.5.77 defun pfLambda . . . 509
15.5.78 defun Return the Body part of a Lambda node . . . 510
15.5.79 defun Return the Rets part of a Lambda node . . . 510
15.5.80 defun Is this a Lambda node? . . . 510
15.5.81 defun Return the Args part of a Lambda node . . . 510
15.5.82 defun Return the Args of a Lambda Node . . . 510
15.5.83 defun Construct a Local node . . . 511
15.5.84 defun Is this a Local node? . . . 511
15.5.85 defun Return the parts of Items of a Local node . . . 511
15.5.86 defun Return the Items of a Local node . . . 511
15.5.87 defun Construct a Loop node . . . 512
15.5.88 defun pfLoop1 . . . 512
15.5.89 defun Is this a Loop node? . . . 512
15.5.90 defun Return the Iterators of a Loop node . . . 512
15.5.91 defun pf0LoopIterators . . . 512
15.5.92 defun pfLp . . . 513
15.5.93 defun Create a Macro node . . . 513
15.5.94 defun Is this a Macro node? . . . 513
15.5.95 defun Return the Lhs of a Macro node . . . 513
15.5.96 defun Return the Rhs of a Macro node . . . 514

15.5.97 defun Construct an MLambda node . . . 514
15.5.98 defun Is this an MLambda node? . . . 514
15.5.99 defun Return the Args of an MLambda . . . 514
15.5.100 defun Return the parts of an MLambda argument . . . 514
15.5.101 defun pfMLambdaBody . . . 515
15.5.102 defun Is this a Not node? . . . 515
15.5.103 defun Return the Arg part of a Not node . . . 515
15.5.104 defun Construct a NoValue node . . . 515
15.5.105 defun Is this a Novalue node? . . . 516
15.5.106 defun Return the Expr part of a Novalue node . . . 516
15.5.107 defun Construct an Or node . . . 516
15.5.108 defun Is this an Or node? . . . 516
15.5.109 defun Return the Left part of an Or node . . . 516
15.5.110 defun Return the Right part of an Or node . . . 517
15.5.111 defun Return the part of a parenthesised expression . . . 517
15.5.112 defun pfPretend . . . 517
15.5.113 defun Is this a Pretend node? . . . 517
15.5.114 defun Return the Expression part of a Pretend node . . . 518
15.5.115 defun Return the Type part of a Pretend node . . . 518
15.5.116 defun Construct a QualType node . . . 518
15.5.117 defun Construct a Restrict node . . . 518
15.5.118 defun Is this a Restrict node? . . . 518
15.5.119 defun Return the Expr part of a Restrict node . . . 519
15.5.120 defun Return the Type part of a Restrict node . . . 519
15.5.121 defun Construct a RetractTo node . . . 519
15.5.122 defun Construct a Return node . . . 519
15.5.123 defun Is this a Return node? . . . 519
15.5.124 defun Return the Expr part of a Return node . . . 520
15.5.125 defun pfReturnNoName . . . 520
15.5.126 defun Construct a ReturnTyped node . . . 520
15.5.127 defun Construct a Rule node . . . 520
15.5.128 defun Return the Lhs of a Rule node . . . 521
15.5.129 defun Return the Rhs of a Rule node . . . 521
15.5.130 defun Is this a Rule node? . . . 521
15.5.131 defun pfSecond . . . 521
15.5.132 defun Construct a Sequence node . . . 521
15.5.133 defun Return the Args of a Sequence node . . . 522
15.5.134 defun Is this a Sequence node? . . . 522
15.5.135 defun Return the parts of the Args of a Sequence node . . . 522
15.5.136 defun Create a Suchthat node . . . 522
15.5.137 defun Is this a SuchThat node? . . . 523
15.5.138 defun Return the Cond part of a SuchThat node . . . 523
15.5.139 defun Create a Tagged node . . . 523
15.5.140 defun Is this a Tagged node? . . . 523
15.5.141 defun Return the Expression portion of a Tagged node . . . 523
15.5.142 defun Return the Tag of a Tagged node . . . 524

15.5.143 defun pfTaggedToTyped . . . 524
15.5.144 defun pfTweakIf . . . 524
15.5.145 defun Construct a Typed node . . . 525
15.5.146 defun Is this a Typed node? . . . 525
15.5.147 defun Return the Type of a Typed node . . . 525
15.5.148 defun Return the Id of a Typed node . . . 525
15.5.149 defun Construct a Typing node . . . 526
15.5.150 defun Return a Tuple node . . . 526
15.5.151 defun Return a Tuple from a List . . . 526
15.5.152 defun Is this a Tuple node? . . . 526
15.5.153 defun Return the Parts of a Tuple node . . . 527
15.5.154 defun Return the parts of a Tuple . . . 527
15.5.155 defun Return a list from a Sequence node . . . 527
15.5.156 defun The comment is attached to all signatutres . . . 527
15.5.157 defun Construct a WDeclare node . . . 528
15.5.158 defun Construct a Where node . . . 528
15.5.159 defun Is this a Where node? . . . 528
15.5.160 defun Return the parts of the Context of a Where node . . . 528
15.5.161 defun Return the Context of a Where node . . . 528
15.5.162 defun Return the Expr part of a Where node . . . 529
15.5.163 defun Construct a While node . . . 529
15.5.164 defun Is this a While node? . . . 529
15.5.165 defun Return the Cond part of a While node . . . 529
15.5.166 defun Construct a With node . . . 530
15.5.167 defun Create a Wrong node . . . 530
15.5.168 defun Is this a Wrong node? . . . 530

16 Pftree to s-expression translation 531
16.0.169 defun Pftree to s-expression translation . . . 531
16.0.170 defun Pftree to s-expression translation inner function . . . 531
16.0.171 defun Convert a Literal to an S-expression . . . 536
16.0.172 defun Convert a float to an S-expression . . . 536
16.0.173 defun Change an Application node to an S-expression . . . 537
16.0.174 defun Convert a SuchThat node to an S-expression . . . 539
16.0.175 defun pfOp2Sex . . . 539
16.0.176 defun pmDontQuote? . . . 540
16.0.177 defun hasOptArgs? . . . 540
16.0.178 defun Convert a Sequence node to an S-expression . . . 541
16.0.179 defun pfSequence2Sex0 . . . 541
16.0.180 defun Convert a loop node to an S-expression . . . 542
16.0.181 defun Change a Collect node to an S-expression . . . 545
16.0.182 defun Convert a Definition node to an S-expression . . . 545
16.0.183 defun Convert a Lambda node to an S-expression . . . 546
16.0.184 defun pfCollectArgTran . . . 547
16.0.185 defun Convert a Lambda node to an S-expression . . . 548
16.0.186 defun Convert a Rule node to an S-expression . . . 548

16.0.187 defun Convert the Lhs of a Rule to an S-expression . . . 549
16.0.188 defun Convert the Rhs of a Rule to an S-expression . . . 549
16.0.189 defun Convert a Rule predicate to an S-expression . . . 549
16.0.190 defun patternVarsOf . . . 551
16.0.191 defun patternVarsOf1 . . . 551
16.0.192 defun pvarPredTran . . . 552
16.0.193 defun Convert the Lhs of a Rule node to an S-expression . . . 552
16.0.194 defun Translate ops into internal symbols . . . 552

17 Stream Utilities **555**
17.0.195 defun npNull . . . 555
17.0.196 defun StreamNull . . . 555

18 Code Piles **557**
18.0.197 defun insertpile . . . 557
18.0.198 defun pilePlusComment . . . 558
18.0.199 defun pilePlusComments . . . 558
18.0.200 defun pileTree . . . 558
18.0.201 defun pileColumn . . . 559
18.0.202 defun pileForests . . . 559
18.0.203 defun pileForest . . . 560
18.0.204 defun pileForest1 . . . 560
18.0.205 defun eqpileTree . . . 561
18.0.206 defun pileCtree . . . 561
18.0.207 defun pileCforest . . . 561
18.0.208 defun enPile . . . 562
18.0.209 defun firstTokPosn . . . 562
18.0.210 defun lastTokPosn . . . 562
18.0.211 defun separatePiles . . . 562

19 Dequeue Functions **565**
19.0.212 defun dqUnit . . . 565
19.0.213 defun dqConcat . . . 565
19.0.214 defun dqAppend . . . 566
19.0.215 defun dqToList . . . 566

20 Message Handling **567**
20.1 The Line Object . . . 567
20.1.1 defun Line object creation . . . 567
20.1.2 defun Line element 0; Extra blanks . . . 567
20.1.3 defun Line element 1; String . . . 567
20.1.4 defun Line element 2; Globlal number . . . 568
20.1.5 defun Line element 2; Set Global number . . . 568
20.1.6 defun Line elemnt 3; Local number . . . 568
20.1.7 defun Line element 4; Place of origin . . . 568
20.1.8 defun Line element 4: Is it a filename? . . . 568

20.1.9 defun Line element 4: Is it a filename? . . . 569
20.1.10 defun Line element 4; Get filename . . . 569
20.2 Messages . . . 569
20.2.1 defun msgCreate . . . 569
20.2.2 defmacro getMsgPosTagOb . . . 570
20.2.3 defmacro getMsgKey . . . 570
20.2.4 defmacro getMsgArgL . . . 570
20.2.5 defmacro getMsgPrefix . . . 570
20.2.6 defmacro setMsgPrefix . . . 571
20.2.7 defmacro getMsgText . . . 571
20.2.8 defmacro setMsgText . . . 571
20.2.9 defmacro getMsgPrefix? . . . 571
20.2.10 defmacro getMsgTag . . . 571
20.2.11 defmacro getMsgTag? . . . 572
20.2.12 defmacro line? . . . 572
20.2.13 defmacro leader? . . . 572
20.2.14 defmacro toScreen? . . . 572
20.2.15 defun ncSoftError . . . 573
20.2.16 defun ncHardError . . . 573
20.2.17 defun desiredMsg . . . 573
20.2.18 defun processKeyedError . . . 574
20.2.19 defun msgOutputter . . . 574
20.2.20 defun listOutputter . . . 575
20.2.21 defun getStFromMsg . . . 575
20.2.22 defvar $preLength . . . 576
20.2.23 defun getPreStL . . . 576
20.2.24 defun getPosStL . . . 576
20.2.25 defun ppos . . . 577
20.2.26 defun remFile . . . 578
20.2.27 defun showMsgPos? . . . 578
20.2.28 defvar $imPrGuys . . . 578
20.2.29 defun msgImPr? . . . 578
20.2.30 defun getMsgCatAttr . . . 579
20.2.31 defun getMsgPos . . . 579
20.2.32 defun getMsgFTTag? . . . 579
20.2.33 defun decideHowMuch . . . 579
20.2.34 defun poNopos? . . . 580
20.2.35 defun poPosImmediate? . . . 580
20.2.36 defun poFileName . . . 580
20.2.37 defun poGetLineObject . . . 581
20.2.38 defun poLinePosn . . . 581
20.2.39 defun listDecideHowMuch . . . 581
20.2.40 defun remLine . . . 582
20.2.41 defun getMsgKey? . . . 582
20.2.42 defun tabbing . . . 582
20.2.43 defvar $toWhereGuys . . . 582

20.2.44 defun getMsgToWhere . . . 582
20.2.45 defun toFile? . . . 583
20.2.46 defun alreadyOpened? . . . 583
20.2.47 defun setMsgForcedAttrList . . . 583
20.2.48 defun setMsgForcedAttr . . . 583
20.2.49 defvar $attrCats . . . 584
20.2.50 defun whichCat . . . 584
20.2.51 defun setMsgCatlessAttr . . . 584
20.2.52 defun putDatabaseStuff . . . 585
20.2.53 defun getMsgInfoFromKey . . . 585
20.2.54 defun setMsgUnforcedAttrList . . . 586
20.2.55 defun setMsgUnforcedAttr . . . 586
20.2.56 defvar $imPrTagGuys . . . 586
20.2.57 defun initImPr . . . 586
20.2.58 defun initToWhere . . . 587
20.2.59 defun Report a bug in the compiler . . . 587
20.2.60 defun processMsgList . . . 587
20.2.61 defun erMsgSort . . . 588
20.2.62 defun erMsgCompare . . . 588
20.2.63 defun compareposns . . . 589
20.2.64 defun erMsgSep . . . 589
20.2.65 defun makeMsgFromLine . . . 589
20.2.66 defun rep . . . 590
20.2.67 defun getLinePos . . . 590
20.2.68 defun getLineText . . . 590
20.2.69 defun queueUpErrors . . . 590
20.2.70 defun thisPosIsLess . . . 592
20.2.71 defun thisPosIsEqual . . . 592
20.2.72 defun redundant . . . 592
20.2.73 defvar $repGuys . . . 593
20.2.74 defun msgNoRep? . . . 593
20.2.75 defun sameMsg? . . . 593
20.2.76 defun processChPosesForOneLine . . . 594
20.2.77 defun poCharPosn . . . 594
20.2.78 defun makeLeaderMsg . . . 595
20.2.79 defun posPointers . . . 595
20.2.80 defun getMsgPos2 . . . 596
20.2.81 defun insertPos . . . 596
20.2.82 defun putFTText . . . 597
20.2.83 defun From . . . 597
20.2.84 defun To . . . 598
20.2.85 defun FromTo . . . 598

21 The Interpreter Syntax **599**
21.1 syntax assignment . . . 599
21.2 syntax blocks . . . 602
21.3 system clef . . . 604
21.4 syntax collection . . . 605
21.5 syntax for . . . 606
21.6 syntax if . . . 610
21.7 syntax iterate . . . 612
21.8 syntax leave . . . 613
21.9 syntax parallel . . . 614
21.10 syntax repeat . . . 616
21.11 syntax suchthat . . . 620
21.12 syntax syntax . . . 621
21.13 syntax while . . . 621

22 Abstract Syntax Trees (ptrees) **623**
22.0.1 defun Construct a leaf token . . . 623
22.0.2 defun Return a part of a node . . . 624
22.0.3 defun Compare a part of a node . . . 624
22.0.4 defun pfNoPosition? . . . 624
22.0.5 defun poNoPosition? . . . 624
22.0.6 defun tokType . . . 625
22.0.7 defun tokPart . . . 625
22.0.8 defun tokPosn . . . 625
22.0.9 defun pfNoPosition . . . 625
22.0.10 defun poNoPosition . . . 625

23 Attributed Structures **627**
23.0.11 defun ncTag . . . 627
23.0.12 defun ncAlist . . . 627
23.0.13 defun ncEltQ . . . 628
23.0.14 defun ncPutQ . . . 628
23.0.15 Special Category Names . . . 629
23.0.16 defvar $EmptyMode . . . 629
23.0.17 defvar $AnonymousFunction . . . 629
23.0.18 defvar $Any . . . 630
23.0.19 defvar $BFtag . . . 630
23.0.20 defvar $Boolean . . . 630
23.0.21 defvar $Category . . . 630
23.0.22 defvar $Domain . . . 630
23.0.23 defvar $Exit . . . 631
23.0.24 defvar $Expression . . . 631
23.0.25 defvar $OutputForm . . . 631
23.0.26 defvar $BigFloat . . . 631
23.0.27 defvar $Float . . . 631
23.0.28 defvar $DoubleFloat . . . 631

23.0.29 defvar $FontTable . . . 632
23.0.30 defvar $Integer . . . 632
23.0.31 defvar $ComplexInteger . . . 632
23.0.32 defvar $Mode . . . 632
23.0.33 defvar $NegativeInteger . . . 632
23.0.34 defvar $NonNegativeInteger . . . 633
23.0.35 defvar $NonPositiveInteger . . . 633
23.0.36 defvar $PositiveInteger . . . 633
23.0.37 defvar $RationalNumber . . . 633
23.0.38 defvar $String . . . 633
23.0.39 defvar $StringCategory . . . 633
23.0.40 defvar $Symbol . . . 634
23.0.41 defvar $Void . . . 634
23.0.42 defvar $QuotientField . . . 634
23.0.43 defvar $FunctionalExpression . . . 634
23.0.44 defvar $defaultFunctionTargets . . . 634
23.0.45 defvar $SmallInteger . . . 635
23.0.46 defvar $SingleFloat . . . 635
23.0.47 defvar $DoubleFloat . . . 635
23.0.48 defvar $SingleInteger . . . 635

24 Function Selection 637
24.0.49 defun ofCategory . . . 637
24.0.50 defun isPartialMode . . . 638
24.0.51 defun hasCaty . . . 638
24.0.52 defun domArg . . . 640
24.0.53 defun domArg2 . . . 640
24.0.54 defun hasSig . . . 640
24.0.55 defun hasAtt . . . 641
24.0.56 defun hasSigAnd . . . 642
24.0.57 defun hasSigOr . . . 643
24.0.58 defun hasAttSig . . . 644
24.0.59 defun hasCate1 . . . 644
24.0.60 defun hasCatExpression . . . 644
24.0.61 defun unifyStruct . . . 645
24.0.62 defun unifyStructVar . . . 646
24.0.63 defun containsVars . . . 647
24.0.64 defun isPatternVar . . . 648
24.0.65 defun containsVars1 . . . 648
24.0.66 defun hasCaty1 . . . 648
24.0.67 defun mkDomPvar . . . 650
24.0.68 defun hasCate . . . 650
24.0.69 defun constructSubst . . . 651
24.0.70 defun hasCateSpecial . . . 651
24.0.71 defun hasCateSpecialNew . . . 652
24.0.72 defun defaultTargetFE . . . 654

24.0.73 defun isEqualOrSubDomain . . . 655

25 Coercions **657**

25.0.74 defun coerceInteractive . . . 658
25.0.75 defun coerceInt . . . 659
25.0.76 defun coerceInt0 . . . 659
25.0.77 defun coerceInt1 . . . 660
25.0.78 defun coerceByFunction . . . 665
25.0.79 defun coerceIntTower . . . 667
25.0.80 defun coerceIntTest . . . 668
25.0.81 defvar coerceConvertMmSelection;AL . . . 669
25.0.82 defun coerceConvertMmSelection . . . 669
25.0.83 defun hasCorrectTarget . . . 670
25.0.84 defun coerceIntPermute . . . 670
25.0.85 defun computeTTTranspositions . . . 671
25.0.86 defun permuteToOrder . . . 672
25.0.87 defun decomposeTypeIntoTower . . . 673
25.0.88 defun reassembleTowerIntoType . . . 673
25.0.89 defun coerceIntCommute . . . 673
25.0.90 defun coerceCommuteTest . . . 674
25.0.91 defun coerceIntTableOrFunction . . . 675
25.0.92 defun coerceByTable . . . 675
25.0.93 defun catchCoerceFailure . . . 676
25.0.94 defun coerceIntSpecial . . . 676
25.0.95 defun coerceIntByMap . . . 677
25.0.96 defun coerceIntByMapInner . . . 678
25.0.97 defun coerceOrThrowFailure . . . 678
25.0.98 defun coercionFailure . . . 679
25.0.99 defun valueArgsEqual? . . . 679
25.0.100 defun algEqual . . . 680
25.0.101 defun coerceIntFromUnion . . . 680
25.0.102 defun coerceInt2Union . . . 680
25.0.103 defun coerceBranch2Union . . . 681
25.0.104 defun coerceIntAlgebraicConstant . . . 682
25.0.105 defun getConstantFromDomain . . . 682
25.0.106 defun compareTypeLists . . . 683
25.0.107 defun coerceIntX . . . 683
25.0.108 defun coerceSubDomain . . . 683
25.0.109 defun coerceImmediateSubDomain . . . 684
25.0.110 defun getSubDomainPredicate . . . 684
25.0.111 defun absolutelyCanCoerceByCheating . . . 685
25.0.112 defun coerceOrRetract . . . 686
25.0.113 defun retract2Specialization . . . 686
25.0.114 defun coerceUnion2Branch . . . 690
25.0.115 defun stripUnionTags . . . 690
25.0.116 defun evalSharpOne . . . 690

25.0.117 defun retractUnderDomain . . . 691
25.0.118 defun coerceRetract . . . 691
25.0.119 defun retractByFunction . . . 692

26 System Command Handling **695**
26.1 Variables Used . . . 696
26.1.1 defvar $systemCommands . . . 696
26.1.2 defvar $syscommands . . . 697
26.1.3 defvar $noParseCommands . . . 698
26.2 Functions . . . 698
26.2.1 defun handleNoParseCommands . . . 698
26.2.2 defun Handle a top level command . . . 699
26.2.3 defun Split block into option block . . . 700
26.2.4 defun Tokenize a system command . . . 700
26.2.5 defun Handle system commands . . . 700
26.2.6 defun Select commands matching this user level . . . 701
26.2.7 defun No command begins with this string . . . 702
26.2.8 defun No option begins with this string . . . 702
26.2.9 defvar $oldline . . . 702
26.2.10 defun No command/option begins with this string . . . 702
26.2.11 defun Option not available at this user level . . . 703
26.2.12 defun Command not available at this user level . . . 703
26.2.13 defun Command not available error message . . . 703
26.2.14 defun satisfiesUserLevel . . . 703
26.2.15 defun hasOption . . . 704
26.2.16 defun terminateSystemCommand . . . 704
26.2.17 defun Terminate a system command . . . 704
26.2.18 defun commandAmbiguityError . . . 705
26.2.19 defun getParserMacroNames . . . 705
26.2.20 defun clearParserMacro . . . 705
26.2.21 defun displayMacro . . . 706
26.2.22 defun displayWorkspaceNames . . . 706
26.2.23 defun getWorkspaceNames . . . 707
26.2.24 defun fixObjectForPrinting . . . 707
26.2.25 defun displayProperties,sayFunctionDeps . . . 708
26.2.26 defun displayValue . . . 710
26.2.27 defun displayType . . . 711
26.2.28 defun getAndSay . . . 712
26.2.29 defun displayProperties . . . 712
26.2.30 defun displayParserMacro . . . 715
26.2.31 defun displayCondition . . . 715
26.2.32 defun interpFunctionDepAlists . . . 716
26.2.33 defun displayModemap . . . 716
26.2.34 defun displayMode . . . 717
26.2.35 defun Split into tokens delimted by spaces . . . 717
26.2.36 defun Convert string tokens to their proper type . . . 718

26.2.37 defun Is the argument string an integer? . . . 718
26.2.38 defun Handle parsed system commands . . . 718
26.2.39 defun Parse a system command . . . 719
26.2.40 defun Get first word in a string . . . 719
26.2.41 defun Unabbreviate keywords in commands . . . 719
26.2.42 defun The command is ambiguous error . . . 720
26.2.43 defun Remove the spaces surrounding a string . . . 721
26.2.44 defun Remove the lisp command prefix . . . 721
26.2.45 defun Handle the)lisp command . . . 722
26.2.46 defun The)boot command is no longer supported . . . 722
26.2.47 defun Handle the)system command . . . 722
26.2.48 defun Handle the)synonym command . . . 722
26.2.49 defun Handle the synonym system command . . . 723
26.2.50 defun printSynonyms . . . 723
26.2.51 defun Print a list of each matching synonym . . . 724
26.2.52 defvar $tokenCommands . . . 724
26.2.53 defvar $InitialCommandSynonymAlist . . . 725
26.2.54 defun Print the current version information . . . 726
26.2.55 defvar $CommandSynonymAlist . . . 727
26.2.56 defun ncloopCommand . . . 727
26.2.57 defun ncloopPrefix? . . . 728
26.2.58 defun selectOptionLC . . . 728
26.2.59 defun selectOption . . . 728
26.3)abbreviations Command . . . 730
26.3.1 abbreviations man page . . . 730
26.3.2 defun abbreviations . . . 731
26.3.3 defun abbreviationsSpad2Cmd . . . 731
26.3.4 defun listConstructorAbbreviations . . . 733
26.4)boot Command . . . 734
26.4.1 boot man page . . . 734
26.5)browse Command . . . 735
26.5.1 browse man page . . . 735
26.6 Overview . . . 735
26.7 Browsers, MathML, and Fonts . . . 736
26.8 The axServer/multiServ loop . . . 737
26.9 The)browse command . . . 737
26.10 The server support code . . . 738
26.11)cd Command . . . 739
26.11.1 cd man page . . . 739
26.12)clear Command . . . 740
26.12.1 clear man page . . . 740
26.12.2 defvar $clearOptions . . . 741
26.12.3 defun clear . . . 741
26.12.4 defvar $clearExcept . . . 742
26.12.5 defun clearSpad2Cmd . . . 742
26.12.6 defun clearCmdSortedCaches . . . 743

26.12.7 defun compiledLookupCheck . . . 744
26.12.8 defvar $functionTable . . . 744
26.12.9 defun clearCmdCompletely . . . 744
26.12.10 defun clearCmdAll . . . 745
26.12.11 defun clearMacroTable . . . 746
26.12.12 defun clearCmdExcept . . . 747
26.12.13 defun clearCmdParts . . . 747
26.13)close Command . . . 750
26.13.1 close man page . . . 750
26.13.2 defun queryClients . . . 751
26.13.3 defun close . . . 751
26.14)compile Command . . . 753
26.14.1 compile man page . . . 753
26.14.2 defvar /editfile . . . 755
26.15)copyright Command . . . 756
26.15.1 copyright man page . . . 756
26.15.2 defun copyright . . . 760
26.15.3 defun trademark . . . 761
26.16)credits Command . . . 762
26.16.1 credits man page . . . 762
26.16.2 defun credits . . . 762
26.17)describe Command . . . 763
26.17.1 describe man page . . . 763
26.17.2 defvar $describeOptions . . . 763
26.17.3 defun Print comment strings from algebra libraries . . . 764
26.17.4 defun describeSpad2Cmd . . . 764
26.17.5 defun cleanline . . . 765
26.17.6 defun flatten . . . 766
26.18)display Command . . . 767
26.18.1 display man page . . . 767
26.18.2 defvar $displayOptions . . . 768
26.18.3 defun display . . . 768
26.18.4 displaySpad2Cmd . . . 769
26.18.5 defun abbQuery . . . 770
26.18.6 defun displayOperations . . . 770
26.18.7 defun yesanswer . . . 771
26.18.8 defun displayMacros . . . 771
26.18.9 defun sayExample . . . 772
26.18.10 defun cleanupLine . . . 773
26.19)edit Command . . . 775
26.19.1 edit man page . . . 775
26.19.2 defun edit . . . 776
26.19.3 defun editSpad2Cmd . . . 776
26.19.4 defun Implement the)edit command . . . 777
26.19.5 defun updateSourceFiles . . . 778
26.20)fin Command . . . 779

26.20.1 fin man page . . . 779
26.20.2 defun Exit from the interpreter to lisp . . . 779
26.21)help Command . . . 780
26.21.1 help man page . . . 780
26.21.2 The top level help command . . . 782
26.21.3 The top level help command handler . . . 782
26.21.4 defun newHelpSpad2Cmd . . . 783
26.22)history Command . . . 785
26.22.1 history man page . . . 785
26.23 Initialized history variables . . . 787
26.23.1 defvar $oldHistoryFileName . . . 788
26.23.2 defvar $historyFileType . . . 788
26.23.3 defvar $historyDirectory . . . 788
26.23.4 defvar $useInternalHistoryTable . . . 788
26.23.5 defun makeHistFileName . . . 789
26.23.6 defun oldHistFileName . . . 789
26.23.7 defun histFileName . . . 789
26.23.8 defun histInputFileName . . . 789
26.23.9 defun initHist . . . 790
26.23.10 defun initHistList . . . 790
26.23.11 The top level history command . . . 791
26.23.12 The top level history command handler . . . 791
26.23.13 defun showHistory . . . 793
26.23.14 defun setHistoryCore . . . 794
26.23.15 defvar $underbar . . . 797
26.23.16 defun writeInputLines . . . 797
26.23.17 defun resetInCoreHist . . . 798
26.23.18 defun changeHistListLen . . . 799
26.23.19 defun updateHist . . . 799
26.23.20 defun updateInCoreHist . . . 800
26.23.21 defun putHist . . . 800
26.23.22 defun recordNewValue . . . 801
26.23.23 defun recordNewValue0 . . . 801
26.23.24 defun recordOldValue . . . 801
26.23.25 defun recordOldValue0 . . . 802
26.23.26 defun undoInCore . . . 802
26.23.27 defun undoChanges . . . 803
26.23.28 defun undoFromFile . . . 803
26.23.29 defun saveHistory . . . 805
26.23.30 defun restoreHistory . . . 806
26.23.31 defun setIOindex . . . 808
26.23.32 defun showInput . . . 808
26.23.33 defun showInOut . . . 809
26.23.34 defun fetchOutput . . . 809
26.23.35 Read the history file using index n . . . 810
26.23.36 Write information of the current step to history file . . . 811

26.23.37 Disable history if an error occurred . . . 812
26.23.38 defun writeHistModesAndValues . . . 812
26.23.39 defun spadrwrite0 . . . 813
26.23.40 defun Random write to a stream . . . 813
26.23.41 defun spadrwrite . . . 813
26.23.42 defun spadrread . . . 814
26.23.43 defun Random read a key from a stream . . . 814
26.23.44 defun unwritable? . . . 814
26.23.45 defun writifyComplain . . . 815
26.23.46 defun safeWritify . . . 815
26.23.47 defun writify,writifyInner . . . 815
26.23.48 defun writify . . . 818
26.23.49 defun spadClosure? . . . 819
26.23.50 defvar $NonNullStream . . . 819
26.23.51 defvar $NullStream . . . 819
26.23.52 defun dewritify,dewritifyInner . . . 820
26.23.53 defun dewritify . . . 823
26.23.54 defun ScanOrPairVec,ScanOrInner . . . 823
26.23.55 defun ScanOrPairVec . . . 824
26.23.56 defun gensymInt . . . 824
26.23.57 defun charDigitVal . . . 824
26.23.58 defun histFileErase . . . 825
26.24)include Command . . . 826
26.24.1 include man page . . . 826
26.24.2 defun ncloopInclude1 . . . 826
26.24.3 Returns the first non-blank substring of the given string . . . 826
26.24.4 Open the include file and read it in . . . 827
26.24.5 Return the include filename . . . 827
26.24.6 Return the next token . . . 827
26.25)library Command . . . 828
26.25.1 library man page . . . 828
26.26)license Command . . . 830
26.26.1 license man page . . . 830
26.26.2 defun license . . . 830
26.27)lisp Command . . . 831
26.27.1 lisp man page . . . 831
26.28)ltrace Command . . . 832
26.28.1 ltrace man page . . . 832
26.28.2 defun The top level)ltrace function . . . 832
26.29)pquit Command . . . 833
26.29.1 pquit man page . . . 833
26.29.2 The top level pquit command . . . 834
26.29.3 The top level pquit command handler . . . 834
26.30)quit Command . . . 835
26.30.1 quit man page . . . 835
26.30.2 The top level quit command . . . 836

26.30.3 The top level quit command handler . . . 836
26.30.4 Leave the Axiom interpreter . . . 836
26.31)read Command . . . 838
26.31.1 read man page . . . 838
26.31.2 defun The)read command . . . 838
26.31.3 defun Implement the)read command . . . 839
26.31.4 defun /read . . . 840
26.32)regress Command . . . 842
26.32.1 regress man page . . . 842
26.32.2 The regress function details . . . 845
26.32.3 defvar *all-tests-ran* . . . 846
26.32.4 defun Scan a spool output file for failures . . . 846
26.32.5 defun Parse test name from the spool command . . . 847
26.32.6 defun Find the next –S marker . . . 847
26.32.7 defun Parse out the test number from –S lines . . . 847
26.32.8 defvar *ok* . . . 848
26.32.9 defun Compare the computed and expected results . . . 848
26.32.10 defun Split the calculated and expect results into lists . . . 849
26.32.11 defun Returns true on –S lines . . . 850
26.32.12 defun Returns true on –E lines . . . 850
26.32.13 defun Returns true on –R lines . . . 851
26.32.14 defun Returns true on –I lines . . . 851
26.32.15 defun Check the last –S line ran . . . 851
26.33)savesystem Command . . . 853
26.33.1 savesystem man page . . . 853
26.33.2 defvar *ThisIsARunningSystem* . . . 853
26.33.3 defun The)savesystem command . . . 854
26.34)set Command . . . 855
26.34.1 set man page . . . 855
26.34.2 Overview . . . 856
26.34.3 Initialize the set variables . . . 856
26.34.4 Reset the workspace variables . . . 857
26.34.5 Display the set option information . . . 858
26.34.6 Display the set variable settings . . . 860
26.34.7 Translate options values to t or nil . . . 861
26.34.8 Translate t or nil to option values . . . 861
26.34.9 The list structure . . . 862
26.35 set breakmode . . . 863
26.35.1 defvar $BreakMode . . . 863
26.36 set debug . . . 864
26.36.1 set debug lambdatype . . . 864
26.36.2 defvar $lambdatype . . . 864
26.37 set compiler . . . 865
26.37.1 set compiler output . . . 865
26.37.2 The set output command handler . . . 865
26.37.3 Describe the set output library arguments . . . 866

26.37.4 defvar output-library . . . 866
26.37.5 Open the output library . . . 866
26.37.6 set compiler input . . . 867
26.37.7 The set input library command handler . . . 867
26.37.8 Describe the set input library arguments . . . 868
26.37.9 Add the input library to the list . . . 868
26.37.10 defvar input-libraries . . . 869
26.37.11 Drop an input library from the list . . . 869
26.38 set debug dalymode . . . 869
26.38.1 defvar dalymode . . . 869
26.39 set expose . . . 870
26.39.1 functions . . . 871
26.39.2 functions cache . . . 871
26.39.3 defvar $cacheAlist . . . 872
26.39.4 The top level set functions cache handler . . . 872
26.39.5 Display a particular cache count . . . 873
26.39.6 defun insertAlist . . . 874
26.39.7 Describe the set functions cache . . . 874
26.39.8 Display all cache counts . . . 875
26.39.9 Describe the cache counts . . . 875
26.39.10 functions compile . . . 876
26.39.11 defvar $compileRecurrence . . . 877
26.40 set fortran . . . 877
26.40.1 set ints2floats . . . 878
26.40.2 defvar $fortInts2Floats . . . 878
26.40.3 set fortindent . . . 879
26.40.4 defvar $fortIndent . . . 879
26.40.5 set fortlength . . . 879
26.40.6 defvar $fortLength . . . 879
26.40.7 set typedecs . . . 880
26.40.8 defvar $printFortranDecs . . . 880
26.40.9 set defaulttype . . . 881
26.40.10 defvar $defaultFortranType . . . 881
26.40.11 set precision . . . 881
26.40.12 defvar $fortranPrecision . . . 882
26.40.13 set intrinsic . . . 882
26.40.14 defvar $useIntrinsicFunctions . . . 882
26.40.15 set explength . . . 883
26.40.16 defvar $maximumFortranExpressionLength . . . 883
26.40.17 set segment . . . 883
26.40.18 defvar $fortranSegment . . . 884
26.40.19 set optlevel . . . 884
26.40.20 defvar $fortranOptimizationLevel . . . 884
26.40.21 set startindex . . . 885
26.40.22 defvar $fortranArrayStartingIndex . . . 885
26.40.23 set calling . . . 885

26.40.24 defvar $fortranTmpDir . . . 886
26.40.25 The top level set fortran calling tempfile handler . . . 886
26.40.26 Validate the output directory . . . 887
26.40.27 Describe the set fortran calling tempfile . . . 887
26.40.28 defvar $fortranDirectory . . . 888
26.40.29 defun setFortDir . . . 889
26.40.30 defun describeSetFortDir . . . 889
26.40.31 defvar $fortranLibraries . . . 890
26.40.32 defun setLinkerArgs . . . 891
26.40.33 defun describeSetLinkerArgs . . . 891
26.41 set hyperdoc . . . 891
26.41.1 fullscreen . . . 892
26.41.2 defvar $fullScreenSysVars . . . 892
26.41.3 mathwidth . . . 893
26.41.4 defvar $historyDisplayWidth . . . 893
26.42 set help . . . 893
26.42.1 fullscreen . . . 894
26.42.2 defvar $useFullScreenHelp . . . 894
26.43 set history . . . 894
26.43.1 defvar $HiFiAccess . . . 895
26.44 set messages . . . 895
26.44.1 set message any . . . 896
26.44.2 defvar $printAnyIfTrue . . . 897
26.44.3 set message autoload . . . 897
26.44.4 defvar $printLoadMsgs . . . 897
26.44.5 set message bottomup . . . 898
26.44.6 defvar $reportBottomUpFlag . . . 898
26.44.7 set message coercion . . . 898
26.44.8 defvar $reportCoerceIfTrue . . . 899
26.44.9 set message dropmap . . . 899
26.44.10 defvar $displayDroppedMap . . . 899
26.44.11 set message expose . . . 900
26.44.12 defvar $giveExposureWarning . . . 900
26.44.13 set message file . . . 900
26.44.14 defvar $printMsgsToFile . . . 901
26.44.15 set message frame . . . 901
26.44.16 defvar $frameMessages . . . 901
26.44.17 set message highlighting . . . 902
26.44.18 defvar $highlightAllowed . . . 902
26.44.19 set message instant . . . 903
26.44.20 defvar $reportInstantiations . . . 903
26.44.21 set message insteach . . . 903
26.44.22 defvar $reportEachInstantiation— . . . 904
26.44.23 set message interponly . . . 904
26.44.24 defvar $reportInterpOnly . . . 904
26.44.25 set message naglink . . . 905

26.44.26 defvar $nagMessages . . . 905
26.44.27 set message number . . . 905
26.44.28 defvar $displayMsgNumber . . . 906
26.44.29 set message prompt . . . 906
26.44.30 defvar $inputPromptType . . . 906
26.44.31 set message selection . . . 907
26.44.32 set . . . 907
26.44.33 defvar $displaySetValue . . . 908
26.44.34 set message startup . . . 908
26.44.35 defvar $displayStartMsgs . . . 908
26.44.36 set message summary . . . 909
26.44.37 defvar $printStatisticsSummaryIfTrue . . . 909
26.44.38 set message testing . . . 910
26.44.39 defvar $testingSystem . . . 910
26.44.40 set message time . . . 910
26.44.41 defvar $printTimeIfTrue . . . 911
26.44.42 set message type . . . 911
26.44.43 defvar $printTypeIfTrue . . . 911
26.44.44 set message void . . . 912
26.44.45 defvar $printVoidIfTrue . . . 912
26.45 set naglink . . . 912
26.45.1 set naglink host . . . 913
26.45.2 defvar $nagHost . . . 913
26.45.3 defun setNagHost . . . 914
26.45.4 defun describeSetNagHost . . . 914
26.45.5 set naglink persistence . . . 914
26.45.6 defvar $fortPersistence . . . 915
26.45.7 defun setFortPers . . . 915
26.45.8 defun describeFortPersistence . . . 916
26.45.9 set naglink messages . . . 916
26.45.10 set naglink double . . . 917
26.45.11 defvar $nagEnforceDouble . . . 917
26.46 set output . . . 917
26.46.1 set output abbreviate . . . 918
26.46.2 defvar $abbreviateTypes . . . 919
26.46.3 set output algebra . . . 919
26.46.4 defvar $algebraFormat . . . 920
26.46.5 defvar $algebraOutputFile . . . 920
26.46.6 defvar $algebraOutputStream . . . 920
26.46.7 defun setOutputAlgebra . . . 921
26.46.8 defun describeSetOutputAlgebra . . . 923
26.46.9 set output characters . . . 923
26.46.10 defun setOutputCharacters . . . 924
26.46.11 set output fortran . . . 926
26.46.12 defvar $fortranFormat . . . 926
26.46.13 defvar $fortranOutputFile . . . 926

26.46.14 defun setOutputFortran . . . 927
26.46.15 defun describeSetOutputFortran . . . 929
26.46.16 set output fraction . . . 930
26.46.17 defvar $fractionDisplayType . . . 930
26.46.18 set output html . . . 931
26.46.19 defvar $htmlFormat . . . 931
26.46.20 defvar $htmlOutputFile . . . 932
26.46.21 defun setOutputHtml . . . 932
26.46.22 defun describeSetOutputHtml . . . 934
26.46.23 set output length . . . 935
26.46.24 defvar $margin . . . 935
26.46.25 defvar $linelength . . . 936
26.46.26 set output mathml . . . 936
26.46.27 defvar $mathmlFormat . . . 937
26.46.28 defvar $mathmlOutputFile . . . 937
26.46.29 defun setOutputMathml . . . 937
26.46.30 defun describeSetOutputMathml . . . 940
26.46.31 set output openmath . . . 940
26.46.32 defvar $openMathFormat . . . 941
26.46.33 defvar $openMathOutputFile . . . 941
26.46.34 defun setOutputOpenMath . . . 942
26.46.35 defun describeSetOutputOpenMath . . . 944
26.46.36 set output script . . . 945
26.46.37 defvar $formulaFormat . . . 945
26.46.38 defvar $formulaOutputFile . . . 945
26.46.39 defun setOutputFormula . . . 946
26.46.40 defun describeSetOutputFormula . . . 948
26.46.41 set output scripts . . . 949
26.46.42 defvar $linearFormatScripts . . . 949
26.46.43 set output showeditor . . . 950
26.46.44 defvar $useEditorForShowOutput . . . 950
26.46.45 set output tex . . . 950
26.46.46 defvar $texFormat . . . 951
26.46.47 defvar $texOutputFile . . . 951
26.46.48 defun setOutputTex . . . 952
26.46.49 defun describeSetOutputTex . . . 954
26.47 quit . . . 955
26.47.1 defvar $quitCommandType . . . 955
26.48 streams . . . 955
26.48.1 set streams calculate . . . 956
26.48.2 defvar $streamCount . . . 956
26.48.3 defun setStreamsCalculate . . . 957
26.48.4 defun describeSetStreamsCalculate . . . 957
26.48.5 set streams showall . . . 958
26.48.6 defvar $streamsShowAll . . . 958
26.49 set system . . . 958

26.49.1 set system functioncode . . . 959
26.49.2 defvar $reportCompilation . . . 959
26.49.3 set system optimization . . . 959
26.49.4 defvar $reportOptimization . . . 960
26.49.5 set system prettyprint . . . 960
26.49.6 defvar $prettyprint . . . 960
26.50 set userlevel . . . 961
26.50.1 defvar $UserLevel . . . 961
26.50.2 defvar $setOptionNames . . . 962
26.51 Set code . . . 962
26.51.1 defun set . . . 962
26.51.2 defun set1 . . . 963
26.52)show Command . . . 966
26.52.1 show man page . . . 966
26.52.2 defun The)show command . . . 967
26.52.3 defun The internal)show command . . . 967
26.52.4 defun reportOperations . . . 969
26.52.5 defun reportOpsFromLisplib0 . . . 971
26.52.6 defun reportOpsFromLisplib1 . . . 971
26.52.7 defun reportOpsFromLisplib . . . 971
26.52.8 defun isExposedConstructor . . . 973
26.52.9 defun displayOperationsFromLisplib . . . 974
26.52.10 defun reportOpsFromUnitDirectly0 . . . 974
26.52.11 defun reportOpsFromUnitDirectly . . . 975
26.52.12 defun getOplistForConstructorForm . . . 977
26.52.13 defun getOplistWithUniqueSignatures . . . 978
26.52.14 defun reportOpsFromUnitDirectly1 . . . 978
26.52.15 defun sayShowWarning . . . 979
26.53)spool Command . . . 980
26.53.1 spool man page . . . 980
26.54)summary Command . . . 981
26.54.1 summary man page . . . 981
26.54.2 defun summary . . . 981
26.55)synonym Command . . . 983
26.55.1 synonym man page . . . 983
26.55.2 defun The)synonym command . . . 984
26.55.3 defun The)synonym command implementation . . . 984
26.55.4 defun Return a sublist of applicable synonyms . . . 984
26.55.5 defun Get the system command from the input line . . . 985
26.55.6 defun Remove system keyword . . . 985
26.55.7 defun processSynonymLine . . . 986
26.56)system Command . . . 987
26.56.1 system man page . . . 987
26.57)tangle Command . . . 988
26.57.1 tangle man page . . . 988
26.58)trademark Command . . . 990

26.58.1 trademark man page . . . 990
26.59)undo Command . . . 991
26.59.1 undo man page . . . 991
26.60 Evaluation . . . 992
26.60.1 defun evalDomain . . . 993
26.60.2 defun mkEvalable . . . 994
26.60.3 defun mkEvalableUnion . . . 995
26.60.4 defun isTaggedUnion . . . 996
26.60.5 defun mkEvalableRecord . . . 996
26.60.6 defun mkEvalableMapping . . . 996
26.60.7 defun evaluateType . . . 996
26.60.8 defun Eval args passed to a constructor . . . 998
26.60.9 defvar $noEvalTypeMsg . . . 1000
26.60.10 defun throwEvalTypeMsg . . . 1000
26.60.11 defun makeOrdinal . . . 1000
26.60.12 defun evaluateSignature . . . 1001
26.60.13 defun recordFrame . . . 1001
26.60.14 defun diffAlist . . . 1002
26.60.15 defun clearFrame . . . 1005
26.61)what Command . . . 1006
26.61.1 what man page . . . 1006
26.61.2 defvar $whatOptions . . . 1007
26.61.3 defun what . . . 1007
26.61.4 defun whatSpad2Cmd,fixpat . . . 1008
26.61.5 defun whatSpad2Cmd . . . 1008
26.61.6 defun Show keywords for)what command . . . 1009
26.61.7 defun The)what commands implementation . . . 1010
26.61.8 defun Find all names contained in a pattern . . . 1011
26.61.9 defun Find function of names contained in pattern . . . 1011
26.61.10 defun satisfiesRegularExpressions . . . 1012
26.61.11 defun filterAndFormatConstructors . . . 1012
26.61.12 defun whatConstructors . . . 1013
26.61.13 Display all operation names containing the fragment . . . 1013
26.62)workfiles Command . . . 1015
26.62.1 workfiles man page . . . 1015
26.62.2 defun workfiles . . . 1015
26.62.3 defun workfilesSpad2Cmd . . . 1015

27 Handlers for Special Forms **1017**
27.0.4 defun getAndEvalConstructorArgument . . . 1018
27.0.5 defun replaceSharps . . . 1018
27.0.6 defun isDomainValuedVariable . . . 1019
27.0.7 defun evalCategory . . . 1019

28 Handling input files **1021**
28.0.8 defun Handle .axiom.input file . . . 1021
28.0.9 defvar boot-line-stack . . . 1021
28.0.10 defvar in-stream . . . 1021
28.0.11 defvar out-stream . . . 1022
28.0.12 defvar file-closed . . . 1022
28.0.13 defvar echo-meta . . . 1022
28.0.14 defvar $noSubsumption . . . 1022
28.0.15 defvar $envHashTable . . . 1022
28.0.16 defun Dynamically add bindings to the environment . . . 1023
28.0.17 defun Fetch a property list for a symbol from CategoryFrame . . . 1023
28.0.18 defun Search for a binding in the environment list . . . 1024
28.0.19 defun Search for a binding in the current environment . . . 1024
28.0.20 defun searchTailEnv . . . 1024

29 Line Handling **1027**
29.0.21 Line Buffer . . . 1027
29.0.22 defstruct line . . . 1027
29.0.23 defvar current-line . . . 1027
29.0.24 defmacro line-clear . . . 1028
29.0.25 defun line-print . . . 1028
29.0.26 defun line-at-end-p . . . 1028
29.0.27 defun line-past-end-p . . . 1028
29.0.28 defun line-next-char . . . 1029
29.0.29 defun line-advance-char . . . 1029
29.0.30 defun line-current-segment . . . 1029
29.0.31 defun line-new-line . . . 1029
29.0.32 defun next-line . . . 1030
29.0.33 defun Advance-Char . . . 1030
29.0.34 defun storeblanks . . . 1030
29.0.35 defun initial-substring . . . 1031
29.0.36 defun get-a-line . . . 1031

30 File Parsing **1033**
30.0.37 defun Bind a variable in the interactive environment . . . 1033
30.0.38 defvar line-handler . . . 1033
30.0.39 defvar $spad-errors . . . 1033
30.0.40 defvar xtokenreader . . . 1034
30.0.41 defun Initialize the spad reader . . . 1034
30.0.42 defun spad-syntax-error . . . 1034
30.0.43 defun spad-long-error . . . 1035
30.0.44 defun spad-short-error . . . 1035
30.0.45 defun spad-error-loc . . . 1036
30.0.46 defun iostat . . . 1036
30.0.47 defun next-lines-show . . . 1036
30.0.48 defun token-stack-show . . . 1037

30.0.49 defun ioclear . . . 1037

31 Handling output 1039
31.1 Special Character Tables . . . 1039
31.1.1 defvar $defaultSpecialCharacters . . . 1039
31.1.2 defvar $plainSpecialCharacters0 . . . 1039
31.1.3 defvar $plainSpecialCharacters1 . . . 1040
31.1.4 defvar $plainSpecialCharacters2 . . . 1040
31.1.5 defvar $plainSpecialCharacters3 . . . 1041
31.1.6 defvar $plainRTspecialCharacters . . . 1041
31.1.7 defvar $RTspecialCharacters . . . 1042
31.1.8 defvar $specialCharacters . . . 1042
31.1.9 defvar $specialCharacterAlist . . . 1043
31.1.10 defun Look up a special character code for a symbol . . . 1043

32 Stream and File Handling 1045
32.0.11 defun make-instream . . . 1045
32.0.12 defun make-outstream . . . 1045
32.0.13 defun make-appendstream . . . 1045
32.0.14 defun defiostream . . . 1046
32.0.15 defun shut . . . 1046
32.0.16 defun eofp . . . 1046
32.0.17 defun makeStream . . . 1047
32.0.18 defun Construct a new input file name . . . 1047
32.0.19 defun getDirectoryList . . . 1047
32.0.20 defun probeName . . . 1048
32.0.21 defun makeFullNamestring . . . 1048
32.0.22 defun Replace a file by erase and rename . . . 1048

33 The Spad Server Mechanism 1049
33.0.23 defun openserver . . . 1049

34 Axiom Build-time Functions 1051
34.0.24 defun spad-save . . . 1051

35 Exposure Groups 1053

36 Databases 1055
36.1 Database structure . . . 1055
36.1.1 kaf File Format . . . 1055
36.1.2 Database Files . . . 1056
36.1.3 defstruct database . . . 1057
36.1.4 defvar *defaultdomain-list* . . . 1058
36.1.5 defvar *operation-hash* . . . 1059
36.1.6 defvar *hasCategory-hash* . . . 1059
36.1.7 defvar *miss* . . . 1059

36.1.8 Database streams . . . 1059
36.1.9 defvar *interp-stream* . . . 1059
36.1.10 defvar *interp-stream-stamp* . . . 1060
36.1.11 defvar *operation-stream* . . . 1060
36.1.12 defvar *operation-stream-stamp* . . . 1060
36.1.13 defvar *browse-stream* . . . 1060
36.1.14 defvar *browse-stream-stamp* . . . 1060
36.1.15 defvar *category-stream* . . . 1061
36.1.16 defvar *category-stream-stamp* . . . 1061
36.1.17 defvar *allconstructors* . . . 1061
36.1.18 defvar *allOperations* . . . 1061
36.1.19 defun Reset all hash tables before saving system . . . 1061
36.1.20 defun Preload algebra into saved system . . . 1062
36.1.21 defun Open the interp database . . . 1064
36.1.22 defun Open the browse database . . . 1065
36.1.23 defun Open the category database . . . 1066
36.1.24 defun Open the operations database . . . 1067
36.1.25 defun Add operations from newly compiled code . . . 1068
36.1.26 defun Show all database attributes of a constructor . . . 1068
36.1.27 defun Set a value for a constructor key in the database . . . 1069
36.1.28 defun Delete a value for a constructor key in the database . . . 1069
36.1.29 defun Get constructor information for a database key . . . 1070
36.1.30 defun The `)library` top level command . . . 1073
36.1.31 defun Read a local filename and update the hash tables . . . 1073
36.1.32 defun Update the database from an nrlib index.kaf file . . . 1075
36.1.33 defun updateDatabase . . . 1077
36.1.34 defvar *sourcefiles* . . . 1077
36.1.35 defun Make new databases . . . 1077
36.1.36 defun saveDependentsHashTable . . . 1081
36.1.37 defun saveUsersHashTable . . . 1081
36.1.38 defun Construct the proper database full pathname . . . 1082
36.1.39 Building the interp.daase from hash tables . . . 1082
36.1.40 defun Write the interp database . . . 1086
36.1.41 Building the browse.daase from hash tables . . . 1087
36.1.42 defun Write the browse database . . . 1088
36.1.43 Building the category.daase from hash tables . . . 1088
36.1.44 defun Write the category database . . . 1089
36.1.45 Building the operation.daase from hash tables . . . 1089
36.1.46 defun Write the operations database . . . 1089
36.1.47 Database support operations . . . 1090
36.1.48 defun Data preloaded into the image at build time . . . 1090
36.1.49 defun Return all constructors . . . 1090
36.1.50 defun Return all operations . . . 1091

37 System Statistics **1093**
37.0.51 defun statisticsInitialization . . . 1093
37.1 Lisp Library Handling . . . 1093
37.1.1 defun loadLib . . . 1093
37.1.2 defun isSystemDirectory . . . 1094
37.1.3 defun loadLibNoUpdate . . . 1095
37.1.4 defun loadFunctor . . . 1095

38 Special Lisp Functions **1097**
38.0.5 defun compiledLookup . . . 1097
38.0.6 defmacro hashCode? . . . 1097
38.0.7 defun basicLookup . . . 1097
38.0.8 defun lookupInDomainVector . . . 1099
38.0.9 defun basicLookupCheckDefaults . . . 1099
38.0.10 defun oldCompLookup . . . 1100
38.0.11 defun NRTevalDomain . . . 1100
38.1 Axiom control structure macros . . . 1101
38.1.1 defun put . . . 1101
38.1.2 defmacro while . . . 1101
38.1.3 defmacro whileWithResult . . . 1101
38.2 Filename Handling . . . 1102
38.2.1 defun namestring . . . 1102
38.2.2 defun pathnameName . . . 1102
38.2.3 defun pathnameType . . . 1102
38.2.4 defun pathnameTypeId . . . 1102
38.2.5 defun mergePathnames . . . 1103
38.2.6 defun pathnameDirectory . . . 1103
38.2.7 defun Axiom pathnames . . . 1103
38.2.8 defun makePathname . . . 1104
38.2.9 defun Delete a file . . . 1104
38.2.10 defun wrap . . . 1104
38.2.11 defun lotsof . . . 1105
38.2.12 defmacro startsId? . . . 1105
38.2.13 defun hput . . . 1105
38.2.14 defmacro hget . . . 1105
38.2.15 defun hkeys . . . 1105
38.2.16 defun digitp . . . 1106
38.2.17 defun pname . . . 1106
38.2.18 defun size . . . 1106
38.2.19 defun strpos . . . 1106
38.2.20 defun strposl . . . 1107
38.2.21 defmacro identp . . . 1107
38.2.22 defun concat . . . 1107
38.2.23 defun canFuncall? . . . 1108
38.2.24 defun brightprint . . . 1108
38.2.25 defun brightprint-0 . . . 1108

38.2.26 defun member . . . 1108
38.2.27 defun messageprint . . . 1109
38.2.28 defun messageprint-1 . . . 1109
38.2.29 defun messageprint-2 . . . 1109
38.2.30 defun sayBrightly1 . . . 1110
38.2.31 defmacro assq . . . 1110
38.2.32 defun A version of GET that works with lists . . . 1110

39 Record, Union, Mapping, and Enumeration 1111

40 Numeric Function Support 1113
40.0.33 defmacro fracpart . . . 1113
40.0.34 defun list to complex conversion . . . 1113
40.0.35 defun complex to list conversion . . . 1113
40.0.36 defun complex to real conversion . . . 1114
40.0.37 defmacro FloatError . . . 1114
40.0.38 defun Rational approximation to $\Gamma(x)$ . . . 1114
40.0.39 defun phiRatapprox . . . 1114
40.0.40 defun Log approximation to $\Gamma(x)$ . . . 1115
40.0.41 defun Stirling's approximation to $\Gamma(x)$ . . . 1115
40.0.42 defun rgammaImpl . . . 1115
40.0.43 defun gammaRatapprox . . . 1116
40.0.44 defun gammaRatkernel . . . 1116
40.0.45 defun Horner's rule of polynomial evaluation . . . 1117
40.0.46 defun Complex implementation of $\Gamma(z)$ . . . 1117
40.0.47 defun Compute the conjugate of $\Gamma(z)$ . . . 1117
40.0.48 defun $\Gamma(z)$ negative real branch . . . 1118
40.0.49 defun PiMinusLogSinPi . . . 1118
40.0.50 defun cgammaG . . . 1118
40.0.51 defun logH . . . 1118
40.0.52 defun $\Gamma(z)$ positive real branch . . . 1119
40.0.53 defun cgammat . . . 1119
40.0.54 defun $\Gamma(z)$ case 2 . . . 1119
40.0.55 defun logS . . . 1120
40.0.56 defun Adjust logS if imaginary part is negative . . . 1120
40.0.57 defun $\Gamma(z)$ case 3 . . . 1120
40.0.58 defun cgammaBernsum . . . 1120
40.0.59 defun BesselI . . . 1121
40.0.60 defun besselIback . . . 1122
40.0.61 defun Backward recurrence for Bessel functions . . . 1122
40.0.62 defun Compute n terms of the chebychev series for f01 . . . 1123
40.0.63 defun chebf01coefmake . . . 1123
40.0.64 defun chebstarevalarr . . . 1124
40.0.65 defun lncgamma . . . 1125
40.0.66 defun rPsiImpl . . . 1125
40.0.67 defun cotdiffeval . . . 1126

40.0.68 defun Amos' w function . . . 1126
40.0.69 defun PsiAsymptoticOrder . . . 1127
40.0.70 defun PsiBack . . . 1127
40.0.71 defvar PsiAsymptoticBern . . . 1128
40.0.72 defun PsiAsymptotic . . . 1128
40.0.73 defun PsiEps . . . 1129
40.0.74 defun PsiIntpart . . . 1129
40.0.75 defun cPsiImpl . . . 1129
40.0.76 defun PsiXotic . . . 1130
40.0.77 defun BesselJ . . . 1130
40.0.78 defun Asymptotic series for BesselJ . . . 1131
40.0.79 defun BesselasymptA . . . 1132
40.0.80 defun BesselasymptB . . . 1132
40.0.81 defun BesselJRecur . . . 1132
40.0.82 defun BesselJAsymptOrder . . . 1133
40.0.83 defun chebf01 . . . 1134

41 Common Lisp Algebra Support 1137
41.1 AlgebraicFunction . . . 1137
41.1.1 defun retract . . . 1137
41.2 Any . . . 1139
41.2.1 defun spad2BootCoerce . . . 1139
41.3 ApplicationProgramInterface . . . 1139
41.3.1 defun Report what domains get instantiated . . . 1139
41.4 Boolean . . . 1139
41.4.1 defun The Boolean = function support . . . 1139
41.5 Char . . . 1140
41.5.1 defun upcase . . . 1140
41.5.2 defun downcase . . . 1140
41.6 ComplexDoubleFloatMatrix . . . 1140
41.6.1 defmacro make-cdouble-matrix . . . 1140
41.6.2 defmacro cdaref2 . . . 1141
41.6.3 defmacro cdsetaref2 . . . 1141
41.6.4 defmacro cdanrows . . . 1141
41.6.5 defmacro cdancols . . . 1142
41.7 ComplexDoubleFloatVector . . . 1142
41.7.1 defmacro make-cdouble-vector . . . 1142
41.7.2 defmacro cdelt . . . 1142
41.7.3 defmacro cdsetelt . . . 1142
41.7.4 defmacro cdlen . . . 1143
41.8 Database . . . 1143
41.8.1 defun Database elt function support . . . 1143
41.9 DirectProduct . . . 1143
41.9.1 defun vec2list . . . 1143
41.10 DoubleFloat . . . 1144
41.10.1 defmacro DFLessThan . . . 1144

41.11 DoubleFloatSpecialFunctions 1144
41.11.1 defun Real Gamma $\Gamma(x)$ 1144
41.11.2 defun Complex Gamma $\Gamma(z)$ 1144
41.11.3 defun The complex logGamma function 1145
41.11.4 defun The real logGamma function 1145
41.11.5 defun The real Psi function 1145
41.11.6 defun The complex Psi function 1145
41.11.7 defun The real BesselJ function 1146
41.11.8 defun The complex BesselJ function 1146
41.11.9 defun The real BesselI function 1146
41.11.10 defun The complex BesselI function 1146
41.11.11 defun The complex hypergeometric function 1147
41.11.12 defmacro DFUnaryMinus 1147
41.11.13 defmacro DFMinusp 1147
41.11.14 defmacro DFZerop 1147
41.11.15 defmacro DFAdd 1148
41.11.16 defmacro DFSubtract 1148
41.11.17 defmacro DFMultiply 1148
41.11.18 defmacro DFIntegerMultiply 1148
41.11.19 defmacro DFMax 1148
41.11.20 defmacro DFMin 1149
41.11.21 defmacro DFEql 1149
41.11.22 defmacro DFDivide 1149
41.11.23 defmacro DFIntegerDivide 1149
41.11.24 defmacro DFSqrt 1149
41.11.25 defmacro DFLogE 1150
41.11.26 defmacro DFLog 1150
41.11.27 defmacro DFIntegerExpt 1150
41.11.28 defmacro DFExpt 1150
41.11.29 defmacro DFExp 1151
41.11.30 defmacro DFSin 1151
41.11.31 defmacro DFCos 1151
41.11.32 defmacro DFTan 1151
41.11.33 defmacro DFAsin 1151
41.11.34 defmacro DFAcos 1152
41.11.35 defmacro DFAtan 1152
41.11.36 defmacro DFAtan2 1152
41.11.37 defmacro DFSinh 1152
41.11.38 defmacro DFCosh 1153
41.11.39 defmacro DFTanh 1153
41.11.40 defmacro DFAsinh 1153
41.11.41 defmacro DFAcosh 1154
41.11.42 defmacro DFAtanh 1154
41.11.43 defun Machine specific float numerator 1154
41.11.44 defun Machine specific float denominator 1154
41.11.45 defun Machine specific float sign 1155

41.11.46 defun Machine specific float bit length . . . 1155
41.11.47 defun Decode floating-point values . . . 1155
41.11.48 defun The cotangent routine . . . 1155
41.11.49 defun The inverse cotangent function . . . 1156
41.11.50 defun The secant function . . . 1156
41.11.51 defun The inverse secant function . . . 1156
41.11.52 defun The cosecant function . . . 1156
41.11.53 defun The inverse cosecant function . . . 1157
41.11.54 defun The hyperbolic cosecant function . . . 1157
41.11.55 defun The hyperbolic cotangent function . . . 1157
41.11.56 defun The hyperbolic secant function . . . 1157
41.11.57 defun The inverse hyperbolic cosecant function . . . 1157
41.11.58 defun The inverse hyperbolic cotangent function . . . 1158
41.11.59 defun The inverse hyperbolic secant function . . . 1158
41.12 DoubleFloatMatrix . . . 1158
41.12.1 defmacro make-double-matrix . . . 1158
41.12.2 defmacro make-double-matrix1 . . . 1158
41.12.3 defmacro daref2 . . . 1159
41.12.4 defmacro dsetaref2 . . . 1159
41.12.5 defmacro danrows . . . 1159
41.12.6 defmacro dancols . . . 1159
41.13 DoubleFloatVector . . . 1159
41.13.1 defmacro dlen . . . 1160
41.13.2 defmacro make-double-vector . . . 1160
41.13.3 defmacro make-double-vector1 . . . 1160
41.13.4 defmacro delt . . . 1160
41.13.5 defmacro dsetelt . . . 1160
41.14 File . . . 1161
41.14.1 defvar *read-place-holder* . . . 1161
41.14.2 defun placep . . . 1161
41.14.3 defun vmread . . . 1161
41.15 FileName . . . 1161
41.15.1 defun FileName filename function implementation . . . 1161
41.15.2 defun FileName filename support function . . . 1162
41.15.3 defun FileName directory function implementation . . . 1162
41.15.4 defun FileName directory function support . . . 1162
41.15.5 defun FileName name function implementation . . . 1162
41.15.6 defun FileName extension function implementation . . . 1163
41.15.7 defun FileName exists? function implementation . . . 1163
41.15.8 defun FileName readable? function implementation . . . 1163
41.15.9 defun FileName writeable? function implementation . . . 1163
41.15.10 defun FileName writeable? function support . . . 1163
41.15.11 defun FileName new function implementation . . . 1164
41.16 IndexedBits . . . 1164
41.16.1 defmacro truth-to-bit . . . 1164
41.16.2 defun IndexedBits new function support . . . 1164

41.16.3 defmacro bit-to-truth . . . 1165
41.16.4 defmacro bvec-elt . . . 1165
41.16.5 defmacro bvec-setelt . . . 1165
41.16.6 defmacro bvec-size . . . 1165
41.16.7 defun IndexedBits concat function support . . . 1165
41.16.8 defun IndexedBits copy function support . . . 1166
41.16.9 defun IndexedBits = function support . . . 1166
41.16.10 defun IndexedBits < function support . . . 1166
41.16.11 defun IndexedBits And function support . . . 1166
41.16.12 defun IndexedBits Or function support . . . 1166
41.16.13 defun IndexedBits xor function support . . . 1167
41.16.14 defun IndexedBits nand function support . . . 1167
41.16.15 defun IndexedBits nor function support . . . 1167
41.16.16 defun IndexedBits not function support . . . 1167
41.17 IndexCard . . . 1167
41.17.1 defun IndexCard origin function support . . . 1167
41.17.2 defun IndexCard origin function support . . . 1168
41.17.3 defun IndexCard elt function support . . . 1168
41.18 IndexedString . . . 1168
41.18.1 defun qenum . . . 1168
41.19 InputForm . . . 1169
41.19.1 defun called by interpret function . . . 1169
41.19.2 defun called by interpret function . . . 1169
41.19.3 defun called by interpret function . . . 1169
41.19.4 defun unparseInputForm . . . 1170
41.20 Integer . . . 1170
41.20.1 defun Integer divide function support . . . 1170
41.20.2 defun Integer quo function support . . . 1170
41.20.3 defun Integer quo function support . . . 1171
41.20.4 defun Integer random function support . . . 1171
41.21 KeyedAccessFile . . . 1171
41.21.1 defun KeyedAccessFile defstream function support . . . 1171
41.21.2 defun KeyedAccessFile defstream function support . . . 1171
41.22 NumberFormats . . . 1172
41.22.1 defun ncParseFromString . . . 1172
41.23 OperationsQuery . . . 1172
41.23.1 defun OperationQuery getDatabase function support . . . 1172
41.24 ParametricLinearEquations . . . 1173
41.24.1 defun algCoerceInteractive . . . 1173
41.25 Plot3d . . . 1173
41.25.1 defvar $numericFailure . . . 1173
41.25.2 defvar $oldBreakMode . . . 1173
41.25.3 defmacro trapNumericErrors . . . 1173
41.26 SingleInteger . . . 1174
41.26.1 defun qsquotient . . . 1174
41.26.2 defun qsremainder . . . 1174

41.26.3 defmacro qsdifference . . . 1174
41.26.4 defmacro qslessp . . . 1174
41.26.5 defmacro qsadd1 . . . 1175
41.26.6 defmacro qssub1 . . . 1175
41.26.7 defmacro qsminus . . . 1175
41.26.8 defmacro qsplus . . . 1175
41.26.9 defmacro qstimes . . . 1175
41.26.10 defmacro qsabsval . . . 1176
41.26.11 defmacro qsoddp . . . 1176
41.26.12 defmacro qszerop . . . 1176
41.26.13 defmacro qsmax . . . 1176
41.26.14 defmacro qsmin . . . 1176
41.27 Table . . . 1177
41.27.1 defun Table InnerTable support . . . 1177
41.28 U8Vector . . . 1177
41.28.1 defmacro qvlenU8 . . . 1177
41.28.2 defmacro eltU8 . . . 1177
41.28.3 defmacro seteltU8 . . . 1178
41.28.4 defun getRefvU8 . . . 1178
41.29 U16Vector . . . 1178
41.29.1 defmacro qvlenU16 . . . 1178
41.29.2 defmacro eltU16 . . . 1178
41.29.3 defmacro seteltU16 . . . 1178
41.29.4 defun getRefvU16 . . . 1179
41.30 U32Vector . . . 1179
41.30.1 defmacro qvlenU32 . . . 1179
41.30.2 defmacro eltU32 . . . 1179
41.30.3 defmacro seteltU32 . . . 1179
41.30.4 defun getRefvU32 . . . 1180
41.31 U8Matrix . . . 1180
41.31.1 defmacro aref2U8 . . . 1180
41.31.2 defmacro setAref2U8 . . . 1180
41.31.3 defmacro anrowsU8 . . . 1180
41.31.4 defmacro ancolsU8 . . . 1180
41.31.5 defmacro makeMatrixU8 . . . 1181
41.31.6 defmacro makeMatrix1U8 . . . 1181
41.32 U16Matrix . . . 1181
41.32.1 defmacro aref2U16 . . . 1181
41.32.2 defmacro setAref2U16 . . . 1181
41.32.3 defmacro anrowsU16 . . . 1182
41.32.4 defmacro ancolsU16 . . . 1182
41.32.5 defmacro makeMatrixU16 . . . 1182
41.32.6 defmacro makeMatrix1U16 . . . 1182
41.33 U32Matrix . . . 1182
41.33.1 defmacro aref2U32 . . . 1182
41.33.2 defmacro setAref2U32 . . . 1183

41.33.3 defmacro anrowsU32 . . . 1183
41.33.4 defmacro ancolsU32 . . . 1183
41.33.5 defmacro makeMatrixU32 . . . 1183
41.33.6 defmacro makeMatrix1U32 . . . 1183
41.34 U32VectorPolynomialOperations . . . 1184
41.34.1 defmacro qsMulAdd6432 . . . 1184
41.34.2 defmacro qsMulMod32 . . . 1184
41.34.3 defmacro qsMod6432 . . . 1184
41.34.4 defmacro qsMulAddMod6432 . . . 1185
41.34.5 defmacro qsMul6432 . . . 1185
41.34.6 defmacro qsDot26432 . . . 1185
41.34.7 defmacro qsDot2Mod6432 . . . 1185
41.35 Void . . . 1185
41.35.1 defun voidValue . . . 1185

42 OpenMath **1187**
42.1 A Technical Overview . . . 1187
42.1.1 The OpenMath Architecture . . . 1187
42.1.2 OpenMath Encodings . . . 1189
42.1.3 Content Dictionaries . . . 1189
42.1.4 OpenMath in Action . . . 1191
42.2 Technical Details . . . 1192
42.3 The Structure of the API . . . 1192
42.4 OpenMath Expressions . . . 1193
42.4.1 Expressions . . . 1193
42.4.2 Symbols . . . 1193
42.4.3 Encoding and Decoding OpenMath Expressions . . . 1193
42.5 Big Integers . . . 1194
42.6 Functions Dealing with OpenMath Devices . . . 1194
42.7 Functions to Write OpenMath Expressions to Devices . . . 1195
42.7.1 Beginning and Ending Objects . . . 1195
42.7.2 Writing Basic Objects . . . 1195
42.7.3 Writing Structured Objects . . . 1196
42.8 Functions to Extract OpenMath Expressions from Devices . . . 1197
42.8.1 Testing the type of the current token . . . 1197
42.8.2 Extracting the current token . . . 1197
42.9 Comments in the SGML/XML Encodings . . . 1200
42.10 I/O Functions for Devices . . . 1200
42.11 Communications . . . 1201
42.11.1 Functions to Initiate an `OMconn` . . . 1201
42.12 Parameters . . . 1202
42.13 Miscellaneous Functions and Variables . . . 1203
42.14 The OM.h header file . . . 1203
42.15 Axiom OpenMath stub functions . . . 1211
42.15.1 Axiom specific functions . . . 1212
42.15.2 defun om-Read . . . 1212

42.15.3 defun om-listCDs . . . 1212
42.15.4 defun om-listSymbols . . . 1212
42.15.5 defun om-supportsCD . . . 1212
42.15.6 defun om-supportsSymbol . . . 1213
42.15.7 Lisp conversion functions . . . 1213
42.15.8 defun om-setDevEncoding . . . 1213
42.15.9 Device manipulation functions . . . 1213
42.15.10 defun om-openFileDev . . . 1213
42.15.11 defun om-openStringDev . . . 1214
42.15.12 defun om-closeDev . . . 1214
42.15.13 Connection manipulation functions . . . 1214
42.15.14 defun om-makeConn . . . 1214
42.15.15 defun om-closeConn . . . 1214
42.15.16 defun om-getConnInDev . . . 1215
42.15.17 defun om-getConnOutDev . . . 1215
42.15.18 Client/Server functions . . . 1215
42.15.19 defun om-bindTCP . . . 1215
42.15.20 defun om-connectTCP . . . 1215
42.15.21 Device input/output functions . . . 1216
42.15.22 defun om-getApp . . . 1217
42.15.23 defun om-getAtp . . . 1217
42.15.24 defun om-getAttr . . . 1217
42.15.25 defun om-getBind . . . 1218
42.15.26 defun om-getBVar . . . 1218
42.15.27 defun om-getByteArray . . . 1218
42.15.28 defun om-getEndApp . . . 1218
42.15.29 defun om-getEndAtp . . . 1218
42.15.30 defun om-getEndAttr . . . 1219
42.15.31 defun om-getEndBind . . . 1219
42.15.32 defun om-getEndBVar . . . 1219
42.15.33 defun om-getEndError . . . 1219
42.15.34 defun om-getEndObject . . . 1219
42.15.35 defun om-getError . . . 1220
42.15.36 defun om-getFloat . . . 1220
42.15.37 defun om-getInt . . . 1220
42.15.38 defun om-getObject . . . 1220
42.15.39 defun om-getString . . . 1220
42.15.40 defun om-getSymbol . . . 1221
42.15.41 defun om-getType . . . 1221
42.15.42 defun om-getVar . . . 1221
42.15.43 defun om-putApp . . . 1221
42.15.44 defun om-putAtp . . . 1221
42.15.45 defun om-putAttr . . . 1222
42.15.46 defun om-putBind . . . 1222
42.15.47 defun om-putBVar . . . 1222
42.15.48 defun om-putByteArray . . . 1222

42.15.49 defun om-putEndApp . . . 1222
42.15.50 defun om-putEndAtp . . . 1223
42.15.51 defun om-putEndAttr . . . 1223
42.15.52 defun om-putEndBind . . . 1223
42.15.53 defun om-putEndBVar . . . 1223
42.15.54 defun om-putEndError . . . 1223
42.15.55 defun om-putEndObject . . . 1224
42.15.56 defun om-putError . . . 1224
42.15.57 defun om-putFloat . . . 1224
42.15.58 defun om-putInt . . . 1224
42.15.59 defun om-putObject . . . 1224
42.15.60 defun om-putString . . . 1225
42.15.61 defun om-putSymbol . . . 1225
42.15.62 defun om-putVar . . . 1225
42.15.63 defun om-stringToStringPtr . . . 1225
42.15.64 defun om-stringPtrToString . . . 1225

43 NRLIB code.lisp support code 1227
43.0.65 defun makeByteWordVec2 . . . 1227
43.0.66 defmacro spadConstant . . . 1227

44 Monitoring execution 1229
44.0.67 defvar *monitor-domains* . . . 1235
44.0.68 defvar *monitor-nrlibs* . . . 1235
44.0.69 defvar *monitor-table* . . . 1235
44.0.70 defstruct monitor-data . . . 1235
44.0.71 defstruct libstream . . . 1236
44.0.72 defun Initialize the monitor statistics hashtable . . . 1236
44.0.73 defun End the monitoring process, we cannot restart . . . 1236
44.0.74 defun Return a list of the monitor-data structures . . . 1236
44.0.75 defun Add a function to be monitored . . . 1237
44.0.76 defun Remove a function being monitored . . . 1237
44.0.77 defun Enable all (or optionally one) function for monitoring . . . 1237
44.0.78 defun Disable all (optionally one) function for monitoring . . . 1238
44.0.79 defun Reset the table count for the table (or a function) . . . 1238
44.0.80 defun Incr the count of fn by 1 . . . 1239
44.0.81 defun Decr the count of fn by 1 . . . 1239
44.0.82 defun Return the monitor information for a function . . . 1239
44.0.83 defun Hang a monitor call on all of the defuns in a file . . . 1240
44.0.84 defun Return a list of the functions with zero count fields . . . 1240
44.0.85 defun Return a list of functions with non-zero counts . . . 1240
44.0.86 defun Write out a list of symbols or structures to a file . . . 1241
44.0.87 defun Save the *monitor-table* in loadable form . . . 1241
44.0.88 defun restore a checkpointed file . . . 1242
44.0.89 defun Printing help documentation . . . 1242
44.0.90 Monitoring algebra files . . . 1244

44.0.91 defun Monitoring algebra code.lsp files . . . 1244
44.0.92 defun Monitor autoloaded files . . . 1245
44.0.93 defun Monitor an nrlib . . . 1245
44.0.94 defun Given a monitor-data item, extract the nrlib name . . . 1245
44.0.95 defun Is this an exposed algebra function? . . . 1246
44.0.96 defun Monitor exposed domains . . . 1246
44.0.97 defun Generate a report of the monitored domains . . . 1247
44.0.98 defun Parse an)abbrev expression for the domain name . . . 1247
44.0.99 defun Given a spad file, report all nrlibs it creates . . . 1248
44.0.100 defun Print percent of functions tested . . . 1248
44.0.101 defun Find all monitored symbols containing the string . . . 1249

45 HyperDoc 1251
45.1 Hyperdoc macro handling and util.ht . . . 1251
45.1.1 defvar $htMacroTable . . . 1251
45.1.2 defvar $primitiveHtCommands . . . 1252
45.1.3 defvar $newPage . . . 1253
45.1.4 defun Build the table of hyperdoc macros . . . 1253
45.1.5 defun Get new command name and number of args . . . 1253
45.1.6 defun Is the first string a prefix of the second? . . . 1254

46 HyperDoc Basic Command support 1255
46.1 Calculus . . . 1255
46.1.1 defun Calculus - Differentiate . . . 1256
46.1.2 defun bcDifferentiateGen . . . 1257
46.1.3 defun Calculus - Do an Indefinite Integral . . . 1257
46.1.4 defun bcIndefiniteIntegrateGen . . . 1258
46.1.5 defun Calculus - Do a Definite Integral . . . 1259
46.1.6 defun bcDefiniteIntegrateGen . . . 1260
46.1.7 defun Calculus - Find a limit . . . 1261
46.1.8 defun Calculus - Do a summation . . . 1261
46.1.9 defun bcSumGen . . . 1262
46.2 Matrix . . . 1263
46.2.1 defun Basic Commands - Matrix . . . 1263
46.3 Draw . . . 1263
46.3.1 defun Basic Commands - Draw . . . 1263
46.3.2 defun Draw - Function of one variable . . . 1264
46.3.3 defun bcDraw2DfunGen . . . 1266
46.3.4 defun Draw - Parametrically defined curve . . . 1266
46.3.5 defun bcDraw2DparGen . . . 1268
46.3.6 defun Draw - Solution to a polynomial equation . . . 1268
46.3.7 defun bcDraw2DSolveGen . . . 1270
46.3.8 defun Draw - Function of two variables . . . 1270
46.3.9 defun bcDraw3DfunGen . . . 1272
46.3.10 defun Draw - Parametrically defined tube . . . 1272
46.3.11 defun bcDraw3DparGen . . . 1274

46.3.12 defun Draw - Parametrically defined surface . . . 1274
46.3.13 defun bcDraw3Dpar1Gen . . . 1276
46.4 Series . . . 1277
46.4.1 defun Basic Commands - Series . . . 1277
46.4.2 defun Series - Expansion . . . 1277
46.4.3 defun bcSeriesExpansionGen . . . 1278
46.4.4 defun Series - Formula . . . 1279
46.4.5 defun Series - Formula - Taylor Series . . . 1280
46.4.6 defun bcTaylorSeriesGen . . . 1281
46.4.7 defun bcSeriesGen . . . 1281
46.4.8 defun Series - Formula - Laurent Series . . . 1282
46.4.9 defun bcLaurentSeriesGen . . . 1283
46.4.10 defun Series - Formula - Puiseux Series . . . 1283
46.4.11 defun bcPuiseuxSeriesGen . . . 1285
46.4.12 defun Solve Basic Command . . . 1285
46.4.13 defun Solve - System of Linear Equations . . . 1286
46.4.14 defun System of Linear Equations - Directly as equations . . . 1287
46.4.15 defun bcLinearSolveEqns1 . . . 1287
46.4.16 defun System of Linear Equations - In matrix form . . . 1288
46.4.17 defun System of Linear Equations - In matrix form direct . . . 1288
46.4.18 defun Solve System of Linear Equations Individual . . . 1289
46.4.19 defun System of Linear Equations In matrix form by formula . . . 1291
46.4.20 defun Solve - System of Polynomial Equations . . . 1292
46.4.21 defun bcSystemSolveEqns1 . . . 1293
46.4.22 defun bcInputSolveInfo . . . 1293
46.4.23 defun Solve - Single Polynomial Equation . . . 1294

47 HyperDoc Reference 1295
47.1 Book . . . 1295
47.2 Topics . . . 1295
47.2.1 Numbers . . . 1295
47.2.2 Polynomials . . . 1295
47.2.3 Functions . . . 1296
47.2.4 Solving Equations . . . 1296
47.2.5 Calculus . . . 1296
47.2.6 Linear Algebra . . . 1296
47.2.7 Graphics . . . 1296
47.2.8 Algebra . . . 1296
47.3 Language . . . 1297
47.4 Examples . . . 1297
47.5 Commands . . . 1297
47.6 Glossary . . . 1297
47.7 Hyperdoc . . . 1297
47.8 Search . . . 1297

48 HyperDoc Topics 1299

49 HyperDoc Browse **1301**

50 HyperDoc Examples **1303**

51 HyperDoc Settings **1305**

52 HyperDoc About **1307**

53 HyperDoc What's New **1309**

54 HyperDoc Support Functions **1311**
54.1 Handling page creation and deletion . . . 1311
54.1.1 defvar $activePageList . . . 1311
54.1.2 defun htpMakeEmptyPage . . . 1311
54.1.3 defun htpDestroyPage . . . 1311
54.2 Handling Axiom command execution . . . 1312
54.2.1 defun Basic Command result page . . . 1312
54.2.2 defun htMakeDoitButton . . . 1313
54.2.3 defun Execute a command from Hyperdoc . . . 1313
54.2.4 defun Execute a string in the interpreter . . . 1313
54.3 Functions creating pages . . . 1314
54.3.1 defun Basic Command Matrix by Formula generate . . . 1315
54.3.2 defun Basic Command generate explicit matrix . . . 1315
54.3.3 defun Basic Command generate matrix . . . 1316
54.3.4 defun Basic Command iteration . . . 1316
54.3.5 defun Sum Basic Command . . . 1317
54.3.6 defun bcProductGen . . . 1317
54.3.7 defun Read Matrix . . . 1318
54.3.8 defun bcSeriesByFormulaGen . . . 1318
54.3.9 defun Real Limit Basic Command . . . 1318
54.3.10 defun Real Limit Basic Command options . . . 1319
54.3.11 defun bcRealLimitGen1 . . . 1320
54.3.12 defun Complex Limit Basic Command . . . 1321
54.3.13 defun bcComplexLimitGen . . . 1322
54.3.14 defvar $systemType . . . 1322
54.3.15 defvar $numberOfEquations . . . 1323
54.3.16 defvar $solutionMethod . . . 1323
54.3.17 defun bcInputEquations . . . 1323
54.3.18 defun Create a variable string . . . 1325
54.3.19 defun bcMakeUnknowns . . . 1325
54.3.20 defun bcMakeEquations . . . 1325
54.3.21 defun bcMakeLinearEquations . . . 1326
54.3.22 defun bcInputEquationsEnd . . . 1326
54.3.23 defun bcSolveEquationsNumerically . . . 1326
54.3.24 defun bcSolveNumerically1 . . . 1327
54.3.25 defun bcSolveEquations . . . 1327

54.3.26 defun Linear Solve Basic Command options . . . 1328
54.3.27 defun bcLinearExtractMatrix . . . 1329
54.3.28 defun Linear Solve Basic Command Inhomogeneous . . . 1329
54.3.29 defun bcLinearSolveMatrixInhomoGen . . . 1330
54.3.30 defun bcLinearSolveMatrixHomo . . . 1330
54.3.31 defun bcLinearMatrixGen . . . 1331
54.3.32 defun linearFinalRequest . . . 1331
54.3.33 defun explainLinear . . . 1332
54.3.34 defun finalExactRequest . . . 1332
54.3.35 defun bcLinearSolveEqnsGen . . . 1332
54.3.36 defun bcGenEquations . . . 1333
54.3.37 defun Output the final formula . . . 1333
54.3.38 defun convert arguments into function call syntax . . . 1333
54.3.39 defun bcString2HyString2 . . . 1334
54.3.40 defun bcString2HyString . . . 1334
54.3.41 defun find a character position in a string . . . 1334
54.3.42 defun Basic Command result page – NAG version . . . 1334
54.3.43 defun bcOptional . . . 1335
54.3.44 defun create a vertical space on a page . . . 1335
54.3.45 defun break a string into words . . . 1335
54.3.46 defun format words into a string . . . 1335
54.3.47 defun format a vector . . . 1336
54.3.48 defun format an error message . . . 1336
54.3.49 defun format intervals . . . 1336
54.3.50 defun Basic Command page not ready . . . 1336
54.3.51 defun pad a string with blanks . . . 1337
54.3.52 defun construct a name string . . . 1337
54.3.53 defun construct a name string . . . 1337
54.3.54 defvar $bcParseOnly . . . 1338
54.3.55 defvar $htLineList . . . 1338
54.3.56 defvar $curpage . . . 1338
54.3.57 HTPage Layout . . . 1338
54.3.58 defun htpName . . . 1339
54.3.59 defun htpSetName . . . 1339
54.3.60 defun htpDomainConditions . . . 1339
54.3.61 defun htpSetDomainConditions . . . 1339
54.3.62 defun htpDomainVariableAlist . . . 1339
54.3.63 defun htpSetDomainVariableAlist . . . 1340
54.3.64 defun htpDomainPvarSubstList . . . 1340
54.3.65 defun htpSetDomainPvarSubstList . . . 1340
54.3.66 defun htpRadioButtonAlist . . . 1340
54.3.67 defun htpButtonValue . . . 1340
54.3.68 defun htpSetRadioButtonAlist . . . 1341
54.3.69 defun htpInputAreaAlist . . . 1341
54.3.70 defun htpSetInputAreaAlist . . . 1341
54.3.71 defun htpAddInputAreaProp . . . 1341

54.3.72 defun htpPropertyList . . . 1342
54.3.73 defun htpProperty . . . 1342
54.3.74 defun htpSetProperty . . . 1342
54.3.75 defun htpLabelInputString . . . 1342
54.3.76 defun htpLabelFilteredInputString . . . 1343
54.3.77 defun replacePercentByDollar,fn . . . 1343
54.3.78 defun replacePercentByDollar . . . 1343
54.3.79 defun htpSetLabelInputString . . . 1343
54.3.80 defun htpLabelSpadValue . . . 1344
54.3.81 defun htpSetLabelSpadValue . . . 1344
54.3.82 defun htpLabelErrorMsg . . . 1344
54.3.83 defun htpSetLabelErrorMsg . . . 1344
54.3.84 defun htpLabelType . . . 1345
54.3.85 defun htpLabelDefault . . . 1345
54.3.86 defun htpLabelSpadType . . . 1345
54.3.87 defun htpLabelFilter . . . 1345
54.3.88 defun htpPageDescription . . . 1346
54.3.89 defun htpSetPageDescription . . . 1346
54.3.90 defun htpAddToPageDescription . . . 1346
54.3.91 defun issue a single hypertex line or group of lines . . . 1346
54.3.92 defun bcHt . . . 1347
54.3.93 defun htSay . . . 1347
54.3.94 defun bcIssueHt . . . 1348
54.3.95 defun mapStringize . . . 1348
54.3.96 defun basicStringize . . . 1348
54.3.97 defun stringize . . . 1349
54.3.98 defun htInitPage . . . 1349
54.3.99 defun htInitPageNoScroll . . . 1349
54.3.100 defun htSayStandard . . . 1350
54.3.101 defun htSayBind . . . 1350
54.3.102 defun htAddHeading . . . 1350
54.3.103 defun htShowPage . . . 1350
54.3.104 defun show the page which has been computed . . . 1351
54.3.105 defun make a page given the description in itemList . . . 1351
54.3.106 defun htMakePage1 . . . 1351
54.3.107 defun htMakeErrorPage . . . 1352
54.3.108 defun htQuote . . . 1352
54.3.109 defun htProcessToggleButtons . . . 1353
54.3.110 defun htProcessBcButtons . . . 1354
54.3.111 defun htProcessBcStrings . . . 1355
54.3.112 defun bcSadFaces . . . 1356
54.3.113 defun htLispLinks . . . 1356
54.3.114 defun htLispMemoLinks . . . 1357
54.3.115 defun htBcLinks . . . 1357
54.3.116 defun htBcLispLinks . . . 1358
54.3.117 defun beforeAfter . . . 1358

54.3.118 defun mkCurryFun . . . 1359
54.3.119 defun htRadioButtons . . . 1359
54.3.120 defun htBcRadioButtons . . . 1360
54.3.121 defun setUpDefault . . . 1361
54.3.122 defun buttonNames . . . 1362
54.3.123 defun htInputStrings . . . 1362
54.3.124 defun htProcessDomainConditions . . . 1363
54.3.125 defun renamePatternVariables . . . 1364
54.3.126 defun renamePatternVariables1 . . . 1364
54.3.127 defun substFromAlist . . . 1365
54.3.128 defun computeDomainVariableAlist . . . 1366
54.3.129 defun pvarCondList . . . 1366
54.3.130 defun pvarCondList1 . . . 1366
54.3.131 defun pvarsOfPattern . . . 1367
54.3.132 defun htMakeTemplates,substLabel . . . 1368
54.3.133 defun htMakeTemplates . . . 1368
54.3.134 defun templateParts . . . 1369
54.3.135 defun htMakeDoneButton . . . 1369
54.3.136 defun htProcessDoneButton . . . 1370
54.3.137 defun htMakeButton . . . 1370
54.3.138 defun bchtMakeButton . . . 1371
54.3.139 defun htProcessDoitButton . . . 1372
54.3.140 defun htDoneButton . . . 1373
54.3.141 defun typeCheckInputAreas . . . 1373
54.3.142 defun checkCondition . . . 1375
54.3.143 defun condErrorMsg . . . 1376
54.3.144 defun parseAndEval . . . 1377
54.3.145 defun parseAndEval1 . . . 1377
54.3.146 defun oldParseString . . . 1378
54.3.147 defun makeSpadCommand . . . 1378
54.3.148 defun htMakeInputList . . . 1378
54.3.149 defun bracketString . . . 1379
54.3.150 defun quoteString . . . 1379
54.3.151 defvar $funnyQuote . . . 1379
54.3.152 defvar $funnyBacks . . . 1379
54.3.153 defun htEscapeString . . . 1380
54.3.154 defun htsv . . . 1380
54.3.155 defun htSetVars . . . 1380
54.3.156 defun htShowSetTree . . . 1380
54.3.157 defun htShowCount . . . 1382
54.3.158 defun htShowSetTreeValue . . . 1383
54.3.159 defun mkSetTitle . . . 1383
54.3.160 defun listOfStrings2String . . . 1383
54.3.161 defun htShowSetPage . . . 1384
54.3.162 defun htShowLiteralsPage . . . 1384
54.3.163 defun htSetLiterals . . . 1384

54.3.164 defun htSetLiteral . . . 1385
54.3.165 defun htShowIntegerPage . . . 1386
54.3.166 defun htSetInteger . . . 1386
54.3.167 defun htShowFunctionPage . . . 1387
54.3.168 defun htShowFunctionPageContinued . . . 1387
54.3.169 defun htSetvarDoneButton . . . 1388
54.3.170 defun htFunctionSetLiteral . . . 1389
54.3.171 defun htSetFunCommand . . . 1389
54.3.172 defun htSetFunCommandContinue . . . 1389
54.3.173 defun htKill . . . 1390
54.3.174 defun htSetNotAvailable . . . 1390
54.3.175 defun htDoNothing . . . 1391
54.3.176 defun htCheck . . . 1391
54.3.177 defun parseWord . . . 1391
54.3.178 defun htCheckList . . . 1392
54.3.179 defun translateYesNoToTrueFalse . . . 1393
54.3.180 defun chkNameList . . . 1393
54.3.181 defun chkPosInteger . . . 1394
54.3.182 defun chkOutputFileName . . . 1394
54.3.183 defun chkDirectory . . . 1394
54.3.184 defun chkNonNegativeInteger . . . 1394
54.3.185 defun chkRange . . . 1395
54.3.186 defun chkAllNonNegativeInteger . . . 1395
54.3.187 defun htMakePathKey,fn . . . 1395
54.3.188 defun htMakePathKey . . . 1396
54.3.189 defun htMarkTree . . . 1396
54.3.190 defun htSetHistory . . . 1396
54.3.191 defun htSetOutputLibrary . . . 1397
54.3.192 defun htSetInputLibrary . . . 1397
54.3.193 defun htSetExpose . . . 1397
54.3.194 defun htSetOutputCharacters . . . 1397
54.3.195 defun htSetLinkerArgs . . . 1397
54.3.196 defun htSetCache . . . 1398
54.3.197 defun htCacheAddChoice . . . 1398
54.3.198 defun htMakeLabel . . . 1399
54.3.199 defun htCacheSet . . . 1400
54.3.200 defun htAllOrNum . . . 1401
54.3.201 defun htCacheOne . . . 1401
54.3.202 defvar $historyDisplayWidth . . . 1402
54.3.203 defvar $newline . . . 1402
54.3.204 defun downlink . . . 1402
54.3.205 defun dbNonEmptyPattern . . . 1402
54.3.206 defun htSystemVariables,gn . . . 1403
54.3.207 defun htSystemVariables,fn . . . 1403
54.3.208 defun htSystemVariables,displayOptions . . . 1403
54.3.209 defun htSystemVariables,functionTail . . . 1405

54.3.210 defun htSystemVariables . . . 1405
54.3.211 defun htSetSystemVariableKind . . . 1407
54.3.212 defun htSetSystemVariable . . . 1408
54.3.213 defun htGloss . . . 1408
54.3.214 defun htGlossPage . . . 1408
54.3.215 defun gatherGlossLines . . . 1410
54.3.216 defun htGlossSearch . . . 1412
54.3.217 defun htGreekSearch . . . 1412
54.3.218 defun htTextSearch . . . 1414
54.3.219 defun htTutorialSearch . . . 1416
54.3.220 defun mkUnixPattern . . . 1417

55 Browser Support Code 1419
55.1 Pages Initiated from HyperDoc Pages . . . 1419
55.1.1 Search routines . . . 1419
55.1.2 defun dKind . . . 1419
55.1.3 defun checkFilter . . . 1419
55.1.4 defun Concatenate words with blanks . . . 1420
55.1.5 defun Make constructor names lowercase . . . 1420
55.1.6 defun string2Constructor . . . 1420
55.1.7 defvar dbDelimiters . . . 1421
55.1.8 defun String to words respecting delimiters . . . 1421
55.1.9 defun Next word respecting delimiters . . . 1421
55.1.10 defun Hyperdoc category search . . . 1424
55.1.11 defun Hyperdoc default domain search . . . 1424
55.1.12 defun Hyperdoc domain search . . . 1424
55.1.13 defun Hyperdoc package search . . . 1425
55.1.14 defun Hyperdoc constructor search . . . 1425
55.1.15 defun Hyperdoc default constructor search . . . 1425
55.1.16 defun Read libdb.text at file-position n . . . 1425
55.1.17 defun String trim with newlines removed . . . 1425
55.1.18 defun Hyperdoc common constructor search . . . 1426
55.1.19 defun conSpecialString? . . . 1427
55.1.20 Page construction . . . 1428
55.1.21 defun conPage . . . 1428
55.1.22 defun gets line quickly for constructor name or abbreviation . . . 1429
55.1.23 defun conPageConEntry . . . 1429
55.1.24 defun kdPageInfo . . . 1430
55.1.25 defun kArgPage . . . 1430
55.1.26 defun mkDomTypeForm . . . 1431
55.1.27 defun domainDescendantsOf . . . 1431
55.2 Branches of Constructor Page . . . 1433
55.2.1 defun kiPage . . . 1433
55.2.2 defun kePage . . . 1434
55.2.3 defun kePageOpAlist . . . 1435
55.2.4 defun kePageDisplay . . . 1436

55.2.5 defun ksPage . . . 1437
55.2.6 defun dbSearchOrder . . . 1438
55.2.7 defun kcPage . . . 1439
55.2.8 defun kcpPage . . . 1442
55.2.9 defun reduceAlistForDomain . . . 1443
55.2.10 defun kcaPage . . . 1443
55.2.11 defun kcdPage . . . 1443
55.2.12 defun kcdoPage . . . 1444
55.2.13 defun kcaPage1 . . . 1444
55.2.14 defun kccPage . . . 1445
55.2.15 defun augmentHasArgs . . . 1446
55.2.16 defun kcdePage . . . 1447
55.2.17 defun getDependentsOfConstructor . . . 1447
55.2.18 defun kcuPage . . . 1448
55.2.19 defun getUsersOfConstructor . . . 1448
55.2.20 defun kcnPage . . . 1449
55.2.21 defun koPageInputAreaUnchanged? . . . 1450
55.2.22 defun kDomainName . . . 1450
55.2.23 defun kArgumentCheck . . . 1451
55.2.24 defun dbMkEvalable . . . 1452
55.2.25 defun topLevelInterpEval . . . 1452
55.2.26 defun kisValidType . . . 1452
55.2.27 defun kCheckArgumentNumbers . . . 1453
55.2.28 defun parseNoMacroFromString . . . 1453
55.2.29 defun mkConform . . . 1454
55.3 Operation Page for a Domain Form from Scratch . . . 1454
55.3.1 defun conOpPage . . . 1454
55.3.2 defun conOpPage1 . . . 1455
55.3.3 defun dbCompositeWithMap . . . 1456
55.3.4 defun dbExtractUnderlyingDomain . . . 1457
55.4 Operation Page from Main Page . . . 1457
55.4.1 defun koPage . . . 1457
55.4.2 defun koPageFromKKPage . . . 1458
55.4.3 defun koPageAux . . . 1458
55.4.4 defun koPageAux1 . . . 1459
55.4.5 defun koaPageFilterByName . . . 1459
55.5 Get Constructor Documentation . . . 1459
55.5.1 defun dbConstructorDoc,hn . . . 1459
55.5.2 defun dbConstructorDoc,gn . . . 1460
55.5.3 defun dbConstructorDoc,fn . . . 1460
55.5.4 defun dbConstructorDoc . . . 1461
55.5.5 defun dbDocTable . . . 1461
55.5.6 defun originsInOrder . . . 1461
55.5.7 defun dbAddDocTable . . . 1462
55.5.8 defun dbGetDocTable,hn . . . 1463
55.5.9 defun dbGetDocTable,gn . . . 1463

55.5.10 defun dbGetDocTable . . . 1464
55.5.11 defun kTestPred . . . 1464
55.5.12 defun dbAddChainDomain . . . 1465
55.5.13 defun dbSubConform . . . 1465
55.5.14 defun dbAddChain . . . 1466
55.6 Constructor Page Menu . . . 1466
55.6.1 defun dbShowCons . . . 1466
55.6.2 defun conPageChoose . . . 1467
55.6.3 defun dbShowCons1 . . . 1467
55.6.4 defun dbConsExposureMessage . . . 1469
55.6.5 defun dbShowConsKindsFilter . . . 1470
55.6.6 defun dbShowConsDoc . . . 1470
55.6.7 defun dbShowConsDoc1 . . . 1470
55.6.8 defun getConstructorDocumentation . . . 1471
55.6.9 defun dbSelectCon . . . 1472
55.6.10 defun dbShowConditions . . . 1472
55.6.11 defun dbConsHeading . . . 1473
55.6.12 defun dbShowConstructorLines . . . 1474
55.6.13 defun bcUnixTable . . . 1474
55.6.14 Special Code for Union, Mapping, and Record . . . 1475
55.6.15 defun dbSpecialDescription . . . 1475
55.6.16 defun dbSpecialOperations . . . 1476
55.6.17 defun dbSpecialExports . . . 1476
55.6.18 defun dbSpecialExpandIfNecessary . . . 1477
55.6.19 defun lefts . . . 1481
55.6.20 Build Library Database (libdb.text,...) . . . 1482
55.6.21 defun dbMkForm . . . 1482
55.6.22 defun libConstructorSig . . . 1482

56 Utility functions 1485
56.1 Utility functions . . . 1485
56.1.1 defun Delete an alist pair given the key . . . 1485
56.1.2 defun readline . . . 1485
56.1.3 defun isWrapped . . . 1485

57 The Proofs 1487

58 The Interpreter 1489

59 The Global Variables 1531
59.1 Star Global Variables . . . 1531
59.1.1 *eof* . . . 1531
59.1.2 *features* . . . 1531
59.1.3 *package* . . . 1531
59.1.4 *standard-input* . . . 1531
59.1.5 *standard-output* . . . 1532

59.1.6 *top-level-hook* . . . 1532
59.2 Dollar Global Variables . . . 1534
59.2.1 $boot . . . 1535
59.2.2 coerceFailure . . . 1535
59.2.3 $currentLine . . . 1535
59.2.4 $displayStartMsgs . . . 1535
59.2.5 $erMsgToss . . . 1535
59.2.6 $frameRecord . . . 1535
59.2.7 $intRestart . . . 1535
59.2.8 $intTopLevel . . . 1536
59.2.9 $IOindex . . . 1536
59.2.10 $lastPos . . . 1536
59.2.11 $libQuiet . . . 1536
59.2.12 $msgDatabaseName . . . 1536
59.2.13 $ncMsgList . . . 1536
59.2.14 $newcompErrorCount . . . 1536
59.2.15 $nopos . . . 1536
59.2.16 $oldHistoryFileName . . . 1537
59.2.17 $okToExecuteMachineCode . . . 1537
59.2.18 $options . . . 1537
59.2.19 $previousBindings . . . 1537
59.2.20 $reportundo . . . 1537
59.2.21 $spad . . . 1537
59.2.22 $SpadServer . . . 1537
59.2.23 $SpadServerName . . . 1537
59.2.24 $systemCommandFunction . . . 1538
59.2.25 top_level . . . 1538
59.2.26 $quitTag . . . 1538
59.2.27 $useInternalHistoryTable . . . 1538

Signatures **1539**

Bibliography **1541**

Index **1545**

Volume 6: Axiom Command

1 Overview **1**

2 The axiom Command **3**
2.0.1 [-ht | -noht] . . . 3
2.0.2 [-gr | -nogr] . . . 3
2.0.3 [-clef | -noclef] . . . 4
2.0.4 [-noiw | -iw] . . . 4
2.0.5 [-ihere | -noihere] . . . 5
2.0.6 [-nox] . . . 5
2.0.7 [-go | -nogo] . . . 6
2.0.8 [-ws wsname] . . . 6
2.0.9 [-list] . . . 6
2.0.10 [-grprog fname] . . . 6
2.0.11 [-htprog fname] . . . 6
2.0.12 [-clefprog fname] . . . 7
2.0.13 [-sessionprog fname] . . . 7
2.0.14 [-clientprog fname] . . . 7
2.0.15 [-h] . . . 7

3 The `sman` program **15**
3.1 include files . . . 15
3.1.1 include/sman.h . . . 16
3.1.2 include/com.h . . . 17
3.1.3 include/bsdsignal.h . . . 19
3.1.4 include/bsdsignal.h1 . . . 19
3.1.5 include/openpty.h1 . . . 19
3.1.6 include/sman.h1 . . . 19
3.1.7 include/session.h1 . . . 20
3.2 sman.c . . . 21
3.2.1 includes . . . 21
3.2.2 variables . . . 21
3.2.3 process_arguments . . . 23
3.2.4 should_I_clef . . . 25
3.2.5 in_X . . . 25
3.2.6 set_up_defaults . . . 26
3.2.7 process_options . . . 26
3.2.8 death_handler . . . 26
3.2.9 sman_catch_signals . . . 27
3.2.10 fix_env . . . 27
3.2.11 init_term_io . . . 27
3.2.12 strPrefix . . . 28
3.2.13 check_spad_proc . . . 28
3.2.14 clean_up_old_sockets . . . 29

3.2.15 fork_you . . . 29
3.2.16 exec_command_env . . . 30
3.2.17 spawn_of_hell . . . 30
3.2.18 start_the_spadclient . . . 31
3.2.19 start_the_local_spadclient . . . 31
3.2.20 start_the_session_manager . . . 32
3.2.21 start_the_hypertex . . . 32
3.2.22 start_the_graphics . . . 32
3.2.23 fork_Axiom . . . 33
3.2.24 start_the_Axiom . . . 34
3.2.25 clean_up_sockets . . . 35
3.2.26 read_from_spad_io . . . 35
3.2.27 read_from_manager . . . 36
3.2.28 manage_spad_io . . . 36
3.2.29 init_spad_process_list . . . 37
3.2.30 print_spad_process_list . . . 38
3.2.31 find_child . . . 38
3.2.32 kill_all_children . . . 38
3.2.33 clean_up_terminal . . . 39
3.2.34 monitor_children . . . 39
3.2.35 main sman . . . 40
3.2.36 sman.c . . . 41

4 Support Routines **43**
4.1 Command Completion . . . 43

5 The `viewman` program **45**

6 The `hypertex` program **47**

7 The `clef` program **49**

8 The `session` program **51**
8.1 session . . . 51
8.1.1 includes . . . 51
8.1.2 variables . . . 51
8.1.3 usr1_handler . . . 52
8.1.4 usr2_handler . . . 52
8.1.5 term_handler . . . 53
8.1.6 pr . . . 53
8.1.7 close_client . . . 53
8.1.8 read_SpadServer_command . . . 55
8.1.9 test_sock_for_process . . . 55
8.1.10 read_menu_client_command . . . 56
8.1.11 read_from_spad_io . . . 57
8.1.12 kill_spad . . . 57

8.1.13 accept_session_connection 58
8.1.14 read_from_session 59
8.1.15 manage_sessions 60
8.1.16 main sessionmanager 61
8.1.17 session 62

9 The `spadclient` program **65**
9.1 spadclient 65

10 The Command Completion List **67**

11 Research Topics **145**
11.1 Proofs 145
11.2 Indefinites 145
11.3 Provisos 145

12 Makefile **147**

Bibliography **149**

Volume 7: Axiom Hyperdoc

1 Overview **1**
1.1 The Original Plan . . . 2
1.2 External Variables . . . 3
1.3 hypertex . . . 3
1.4 htsearch . . . 4
1.5 spadbuf . . . 4
1.6 hthits . . . 4
1.7 ex2ht . . . 4
1.8 htadd . . . 4

2 The hypertex language **5**

3 Hypertex Call Graph **29**

4 include **81**
4.1 include/actions.h . . . 81
4.2 include/rgb.h . . . 83
4.3 include/spadcolors.h . . . 84
4.4 include/addfile.h1 . . . 85
4.5 include/all-hyper-proto.h1 . . . 85
4.6 include/bsdsignal.h . . . 86
4.7 include/bsdsignal.h1 . . . 86
4.8 include/com.h . . . 86
4.9 include/cond.h1 . . . 88
4.10 include/cursor.h1 . . . 88
4.11 include/debug.h . . . 89
4.12 include/dialog.h1 . . . 89
4.13 include/display.h1 . . . 90
4.14 include/edible.h . . . 90
4.15 include/edible.h1 . . . 93
4.16 include/edin.h1 . . . 94
4.17 include/event.h1 . . . 94
4.18 include/ex2ht.h1 . . . 95
4.19 include/extent1.h1 . . . 96
4.20 include/extent2.h1 . . . 96
4.21 include/fnct-key.h1 . . . 97
4.22 include/form-ext.h1 . . . 97
4.23 include/group.h1 . . . 98
4.24 include/halloc.h1 . . . 98
4.25 include/hash.h . . . 98
4.26 include/hash.h1 . . . 99
4.27 include/htadd.h1 . . . 99
4.28 include/hterror.h1 . . . 100

4.29 include/hthits.h1 . . . 100
4.30 include/htinp.h1 . . . 100
4.31 include/hyper.h1 . . . 101
4.32 include/initx.h1 . . . 101
4.33 include/input.h1 . . . 102
4.34 include/item.h1 . . . 102
4.35 include/keyin.h1 . . . 102
4.36 include/lex.h1 . . . 103
4.37 include/macro.h1 . . . 103
4.38 include/mem.h1 . . . 104
4.39 include/parse-aux.h1 . . . 104
4.40 include/parse.h1 . . . 105
4.41 include/parse-input.h1 . . . 106
4.42 include/parse-paste.h1 . . . 106
4.43 include/parse-types.h1 . . . 106
4.44 include/pixmap.h1 . . . 107
4.45 include/prt.h1 . . . 107
4.46 include/readbitmap.h1 . . . 108
4.47 include/scrollbar.h1 . . . 108
4.48 include/show-types.h1 . . . 109
4.49 include/sockio-c.h1 . . . 109
4.50 include/spadbuf.h1 . . . 110
4.51 include/spadcolors.h1 . . . 111
4.52 include/spadint.h1 . . . 111
4.53 include/titlebar.h1 . . . 112
4.54 include/util.h1 . . . 112
4.55 include/wct.h1 . . . 112

5 Shared Code **115**
5.0.1 BeStruct . . . 115
5.1 Shared Code for file handling . . . 115
5.1.1 strpostfix . . . 115
5.1.2 extendHT . . . 116
5.1.3 buildHtFilename . . . 116
5.1.4 pathname . . . 118
5.1.5 htFileOpen . . . 118
5.1.6 dbFileOpen . . . 119
5.1.7 tempFileOpen . . . 120
5.2 Shared Code for Hash Table Handling . . . 120
5.2.1 halloc . . . 120
5.2.2 hashInit . . . 121
5.2.3 freeHash . . . 121
5.2.4 hashInsert . . . 122
5.2.5 hashFind . . . 122
5.2.6 hashReplace . . . 122
5.2.7 hashDelete . . . 123

5.2.8 hashMap . . . 123
5.2.9 hashCopyEntry . . . 124
5.2.10 hashCopyTable . . . 124
5.2.11 stringHash . . . 124
5.2.12 stringEqual . . . 125
5.2.13 allocString . . . 125
5.3 Shared Code for Error Handling . . . 125
5.3.1 jump . . . 125
5.3.2 dumpToken . . . 125
5.3.3 printPageAndFilename . . . 126
5.3.4 printNextTenTokens . . . 126
5.3.5 printToken . . . 127
5.3.6 tokenName . . . 127
5.3.7 htperror . . . 129
5.4 Shared Code for Lexical Analyzer . . . 129
5.4.1 parserInit . . . 130
5.4.2 initScanner . . . 130
5.4.3 saveScannerState . . . 131
5.4.4 restoreScannerState . . . 131
5.4.5 ungetChar . . . 132
5.4.6 getChar . . . 132
5.4.7 getChar1 . . . 133
5.4.8 ungetToken . . . 134
5.4.9 getToken . . . 134
5.4.10 pushBeStack . . . 137
5.4.11 checkAndPopBeStack . . . 138
5.4.12 clearBeStack . . . 138
5.4.13 beType . . . 139
5.4.14 beginType . . . 140
5.4.15 endType . . . 141
5.4.16 keywordType . . . 142
5.4.17 getExpectedToken . . . 142
5.4.18 spadErrorHandler . . . 143
5.4.19 resetConnection . . . 143
5.4.20 spadBusy . . . 144
5.4.21 connectSpad . . . 144
5.5 htadd shared code . . . 144
5.6 hypertex shared code . . . 148

6 Shared include files **153**
6.1 debug.c . . . 153
6.2 include/hyper.h . . . 153

7 The spadbuf function **165**
7.1 spadbuf Call Graph . . . 165
7.2 Constants and Headers . . . 166
7.2.1 System includes . . . 166
7.2.2 Local includes . . . 166
7.3 externs . . . 167
7.4 local variables . . . 167
7.5 Code . . . 167
7.5.1 spadbufInterHandler . . . 168
7.5.2 spadbufFunctionChars . . . 168
7.5.3 interpIO . . . 168
7.5.4 . . . 169
7.5.5 main . . . 170

8 The ex2ht function **173**
8.1 ex2ht Call Graph . . . 173
8.2 ex2ht Source Code . . . 174
8.3 Constants and Headers . . . 174
8.3.1 System includes . . . 174
8.3.2 Local includes . . . 174
8.4 defines . . . 175
8.5 local variables . . . 175
8.6 Code . . . 175
8.6.1 allocString . . . 175
8.6.2 strPrefix . . . 175
8.6.3 getExTitle . . . 176
8.6.4 exToHt . . . 176
8.6.5 emitHeader . . . 177
8.6.6 emitFooter . . . 178
8.6.7 emitMenuEntry . . . 178
8.6.8 emitSpadCommand . . . 178
8.6.9 openCoverPage . . . 179
8.6.10 closeCoverPage . . . 179
8.6.11 closeCoverFile . . . 179
8.6.12 emitCoverLink . . . 179
8.6.13 addFile . . . 180
8.6.14 main . . . 180

9 The htadd command **181**
9.1 htadd Call Graph . . . 181
9.2 Constants and Headers . . . 185
9.2.1 System includes . . . 185
9.2.2 structs . . . 186
9.2.3 Local includes . . . 186
9.2.4 extern references . . . 186
9.2.5 defines . . . 186

9.2.6 forward declarations . . . 187
9.2.7 local variables . . . 187
9.3 The Shared Code . . . 188
9.4 Code . . . 188
9.4.1 parseArgs . . . 188
9.4.2 writable . . . 189
9.4.3 buildDBFilename . . . 189
9.4.4 addfile . . . 190
9.4.5 updateDB . . . 192
9.4.6 addNewPages . . . 193
9.4.7 copyFile . . . 194
9.4.8 getFilename . . . 194
9.4.9 deleteFile . . . 195
9.4.10 deleteDB . . . 195
9.4.11 main . . . 196

10 The hthits function **199**
10.1 hthits Call Graph . . . 199
10.2 Constants and Headers . . . 200
10.2.1 System includes . . . 200
10.2.2 defines . . . 201
10.2.3 structs . . . 201
10.2.4 Local includes . . . 201
10.2.5 local variables . . . 201
10.2.6 cmdline . . . 202
10.2.7 handleHtdb . . . 202
10.2.8 handleFile . . . 202
10.2.9 handleFilePages . . . 204
10.2.10 handlePage . . . 205
10.2.11 searchPage . . . 205
10.2.12 squirt . . . 206
10.2.13 splitpage . . . 206
10.2.14 untexbuf . . . 207
10.2.15 badDB . . . 208
10.2.16 regerr . . . 208
10.2.17 main . . . 208

11 The hypertex command **209**
11.1 Constants and Headers . . . 209
11.1.1 System includes . . . 209
11.2 structs . . . 210
11.2.1 Local includes . . . 210
11.3 structs . . . 210
11.4 defines . . . 211
11.5 externs . . . 214
11.6 local variables . . . 217

11.7 The Shared Code . . . 221
11.8 Code . . . 225
11.8.1 sigusr2Handler . . . 225
11.8.2 sigcldHandler . . . 225
11.8.3 cleanSocket . . . 226
11.8.4 initHash . . . 226
11.8.5 initPageStructs . . . 226
11.8.6 checkArguments . . . 227
11.8.7 makeServerConnections . . . 228
11.9 Condition Handling . . . 229
11.9.1 insertCond . . . 229
11.9.2 changeCond . . . 230
11.9.3 checkMemostack . . . 230
11.9.4 checkCondition . . . 231
11.10 Dialog Handling . . . 232
11.10.1 redrawWin . . . 232
11.10.2 mystrncpy . . . 232
11.10.3 incLineNumbers . . . 232
11.10.4 decLineNumbers . . . 232
11.10.5 decreaseLineNumbers . . . 233
11.10.6 overwriteBuffer . . . 233
11.10.7 moveSymForward . . . 234
11.10.8 clearCursorline . . . 235
11.10.9 insertBuffer . . . 236
11.10.10 addBufferToSym . . . 238
11.10.11 drawInputsymbol . . . 238
11.10.12 updateInputsymbol . . . 239
11.10.13 drawCursor . . . 239
11.10.14 moveCursorHome . . . 240
11.10.15 moveCursorEnd . . . 240
11.10.16 void moveCursorForward . . . 241
11.10.17 moveCursorDown . . . 241
11.10.18 moveCursorUp . . . 242
11.10.19 clearCursor . . . 243
11.10.20 moveCursorBackward . . . 243
11.10.21 moveRestBack . . . 244
11.10.22 deleteRestOfLine . . . 244
11.10.23 backOverEoln . . . 246
11.10.24 moveBackOneChar . . . 247
11.10.25 backOverChar . . . 249
11.10.26 deleteEoln . . . 249
11.10.27 deleteOneChar . . . 250
11.10.28 deleteChar . . . 251
11.10.29 doughEnter . . . 252
11.10.30 enterNewLine . . . 253
11.10.31 dialog . . . 254

11.11 Format and Display a page . . . 257
11.11.1 showPage . . . 257
11.11.2 exposePage . . . 259
11.11.3 scrollPage . . . 260
11.11.4 pastePage . . . 260
11.12 Event Handling . . . 261
11.12.1 mainEventLoop . . . 261
11.12.2 handleEvent . . . 263
11.12.3 createWindow . . . 265
11.12.4 quitHyperDoc . . . 265
11.12.5 findPage . . . 266
11.12.6 downlink . . . 267
11.12.7 memolink . . . 267
11.12.8 killAxiomPage . . . 267
11.12.9 killPage . . . 268
11.12.10 returnlink . . . 268
11.12.11 uplink . . . 268
11.12.12 windowlinkHandler . . . 269
11.12.13 makeWindowLink . . . 269
11.12.14 dispwindowlinkHandler . . . 269
11.12.15 pasteButton . . . 270
11.12.16 helpForHyperDoc . . . 270
11.12.17 findButtonInList . . . 271
11.12.18 getHyperLink . . . 271
11.12.19 handleButton . . . 271
11.12.20 exitHyperDoc . . . 275
11.12.21 setWindow . . . 276
11.12.22 clearExposures . . . 277
11.12.23 getNewWindow . . . 277
11.12.24 setCursor . . . 279
11.12.25 changeCursor . . . 279
11.12.26 handleMotionEvent . . . 280
11.12.27 initCursorState . . . 280
11.12.28 initCursorStates . . . 280
11.12.29 makeBusyCursor . . . 281
11.12.30 makeBusyCursors . . . 281
11.12.31 HyperDocErrorHandler . . . 281
11.12.32 setErrorHandlers . . . 282
11.13 Line Extent Computation . . . 282
11.13.1 computeInputExtent . . . 282
11.13.2 computePunctuationExtent . . . 283
11.13.3 computeWordExtent . . . 284
11.13.4 computeVerbatimExtent . . . 284
11.13.5 computeSpadsrctxtExtent . . . 285
11.13.6 computeDashExtent . . . 285
11.13.7 computeTextExtent . . . 286

11.13.8 computeBeginItemsExtent . . . 292
11.13.9 computeItemExtent . . . 293
11.13.10 computeMitemExtent . . . 293
11.13.11 endifExtent . . . 293
11.13.12 computeIfcondExtent . . . 294
11.13.13 computeCenterExtent . . . 295
11.13.14 computeBfExtent . . . 295
11.13.15 computeEmExtent . . . 296
11.13.16 computeItExtent . . . 296
11.13.17 computeRmExtent . . . 296
11.13.18 computeButtonExtent . . . 297
11.13.19 endbuttonExtent . . . 297
11.13.20 computePastebuttonExtent . . . 298
11.13.21 endpastebuttonExtent . . . 298
11.13.22 computePasteExtent . . . 299
11.13.23 computeSpadcommandExtent . . . 299
11.13.24 computeSpadsrcExtent . . . 300
11.13.25 endSpadcommandExtent . . . 301
11.13.26 endSpadsrcExtent . . . 301
11.13.27 computeMboxExtent . . . 302
11.13.28 computeBoxExtent . . . 302
11.13.29 computeIrExtent . . . 303
11.13.30 computeImageExtent . . . 303
11.13.31 computeTableExtent . . . 304
11.13.32 computeTitleExtent . . . 305
11.13.33 computeHeaderExtent . . . 305
11.13.34 computeFooterExtent . . . 306
11.13.35 computeScrollingExtent . . . 307
11.13.36 startNewline . . . 307
11.13.37 centerNodes . . . 308
11.13.38 punctuationWidth . . . 308
11.13.39 inputStringWidth . . . 308
11.13.40 wordWidth . . . 309
11.13.41 verbatimWidth . . . 309
11.13.42 widthOfDash . . . 309
11.13.43 textWidth . . . 310
11.13.44 totalWidth . . . 313
11.13.45 initExtents . . . 315
11.13.46 initTitleExtents . . . 316
11.13.47 initText . . . 316
11.13.48 textHeight . . . 316
11.13.49 textHeight1 . . . 317
11.13.50 maxX . . . 319
11.13.51 Xvalue . . . 320
11.13.52 trailingSpace . . . 322
11.13.53 insertBitmapFile . . . 322

11.13.54 insertPixmapFile . . . 323
11.13.55 plh . . . 324
11.14 Handling forms . . . 324
11.14.1 computeFormPage . . . 324
11.14.2 windowWidth . . . 324
11.14.3 windowHeight . . . 325
11.14.4 formHeaderExtent . . . 325
11.14.5 formFooterExtent . . . 325
11.14.6 formScrollingExtent . . . 326
11.15 Managing the HyperDoc group stack . . . 326
11.15.1 popGroupStack . . . 326
11.15.2 pushGroupStack . . . 327
11.15.3 initGroupStack . . . 327
11.15.4 emTopGroup . . . 328
11.15.5 rmTopGroup . . . 328
11.15.6 lineTopGroup . . . 328
11.15.7 bfTopGroup . . . 328
11.15.8 ttTopGroup . . . 329
11.15.9 pushActiveGroup . . . 329
11.15.10 pushSpadGroup . . . 329
11.15.11 initTopGroup . . . 330
11.15.12 enterTopGroup . . . 330
11.15.13 copyGroupStack . . . 330
11.15.14 freeGroupStack . . . 331
11.16 Handle input, output, and Axiom communication . . . 331
11.16.1 makeRecord . . . 331
11.16.2 verifyRecord . . . 332
11.16.3 ht2Input . . . 332
11.16.4 makeInputFileName . . . 333
11.16.5 makePasteFileName . . . 333
11.16.6 makeTheInputFile . . . 333
11.16.7 makeInputFileFromPage . . . 334
11.16.8 strCopy . . . 335
11.16.9 inListAndNewer . . . 336
11.16.10 makeInputFileList . . . 337
11.16.11 printPasteLine . . . 337
11.16.12 getSpadOutput . . . 338
11.16.13 getGraphOutput . . . 338
11.16.14 sendCommand . . . 339
11.16.15 printPaste . . . 339
11.16.16 printGraphPaste . . . 340
11.17 X Window window initialization code . . . 341
11.17.1 initializeWindowSystem . . . 341
11.17.2 initTopWindow . . . 342
11.17.3 openFormWindow . . . 343
11.17.4 initFormWindow . . . 344

11.17.5 setNameAndIcon . . . 345
11.17.6 getBorderProperties . . . 345
11.17.7 openWindow . . . 346
11.17.8 setSizeHints . . . 347
11.17.9 getGCs . . . 348
11.17.10 loadFont . . . 349
11.17.11 ingItColorsAndFonts . . . 350
11.17.12 hangeText . . . 353
11.17.13 getColor . . . 353
11.17.14 nergeDatabases . . . 354
11.17.15 sIt850 . . . 355
11.18 Handling user page interaction . . . 356
11.18.1 fillBox . . . 356
11.18.2 toggleInputBox . . . 356
11.18.3 toggleRadioBox . . . 357
11.18.4 clearRbs . . . 357
11.18.5 changeInputFocus . . . 357
11.18.6 nextInputFocus . . . 358
11.18.7 prevInputFocus . . . 359
11.18.8 returnItem . . . 359
11.18.9 deleteItem . . . 360
11.19 Manipulate the item stack . . . 360
11.19.1 pushItemStack . . . 360
11.19.2 clearItemStack . . . 361
11.19.3 popItemStack . . . 361
11.19.4 copyItemStack . . . 361
11.19.5 freeItemStack . . . 362
11.20 Keyboard handling . . . 362
11.20.1 handleKey . . . 362
11.20.2 getModifierMask . . . 365
11.20.3 initKeyin . . . 366
11.21 Handle page macros . . . 366
11.21.1 scanHyperDoc . . . 366
11.21.2 number . . . 367
11.21.3 loadMacro . . . 368
11.21.4 initParameterElem . . . 369
11.21.5 pushParameters . . . 369
11.21.6 popParameters . . . 370
11.21.7 parseMacro . . . 370
11.21.8 getParameterStrings . . . 371
11.21.9 parseParameters . . . 373
11.22 Memory management routines . . . 373
11.22.1 freeIfNonNULL . . . 373
11.22.2 allocHdWindow . . . 373
11.22.3 freeHdWindow . . . 374
11.22.4 allocNode . . . 375

11.22.5 freeNode . . . 375
11.22.6 allocIfnode . . . 379
11.22.7 allocCondnode . . . 379
11.22.8 freeCond . . . 379
11.22.9 allocPage . . . 379
11.22.10 freePage . . . 380
11.22.11 freePaste . . . 381
11.22.12 freePastebutton . . . 381
11.22.13 freePastearea . . . 382
11.22.14 freeString . . . 382
11.22.15 freeDepend . . . 383
11.22.16 dontFree . . . 383
11.22.17 freeLines . . . 383
11.22.18 freeInputItem . . . 383
11.22.19 freeInputList . . . 384
11.22.20 freeInputBox . . . 384
11.22.21 freeRadioBoxes . . . 384
11.22.22 allocInputline . . . 385
11.22.23 allocPasteNode . . . 385
11.22.24 allocPatchstore . . . 385
11.22.25 freePatch . . . 386
11.22.26 allocInputbox . . . 386
11.22.27 allocRbs . . . 386
11.22.28 allocButtonList . . . 387
11.22.29 freeButtonList . . . 387
11.22.30 resizeBuffer . . . 387
11.23 Page parsing routines . . . 388
11.23.1 PushMR . . . 388
11.23.2 PopMR . . . 388
11.23.3 loadPage . . . 388
11.23.4 displayPage . . . 389
11.23.5 formatPage . . . 390
11.23.6 parseFromString . . . 390
11.23.7 parseTitle . . . 390
11.23.8 parseHeader . . . 391
11.23.9 initParsePage . . . 392
11.23.10 initParsePatch . . . 392
11.23.11 parsePage . . . 393
11.23.12 parseHyperDoc . . . 393
11.23.13 parsePageFromSocket . . . 399
11.23.14 parsePageFromUnixfd . . . 400
11.23.15 startScrolling . . . 401
11.23.16 startFooter . . . 401
11.23.17 endAPage . . . 402
11.23.18 parseReplacepage . . . 403
11.23.19 windowEqual . . . 403

11.23.20windowCode . . . 403
11.23.21windowId . . . 403
11.23.22readHtDb . . . 404
11.23.23readHtFile . . . 405
11.23.24makeLinkWindow . . . 408
11.23.25makePasteWindow . . . 409
11.23.26makeSpecialPage . . . 410
11.23.27main . . . 410
11.23.28addDependencies . . . 410
11.23.29isNumber . . . 411
11.23.30parserError . . . 412
11.23.31getFilename . . . 412
11.23.32getInputString . . . 413
11.23.33getWhere . . . 413
11.23.34findFp . . . 414
11.24Handle InputString, SimpleBox, RadioBox input . . . 415
11.24.1 makeInputWindow . . . 415
11.24.2 makeBoxWindow . . . 415
11.24.3 initializeDefault . . . 416
11.24.4 parseInputstring . . . 417
11.24.5 parseSimplebox . . . 418
11.24.6 parseRadiobox . . . 419
11.24.7 addBoxToRbList . . . 421
11.24.8 checkOthers . . . 422
11.24.9 insertItem . . . 422
11.24.10initPasteItem . . . 423
11.24.11repasteItem . . . 423
11.24.12currentItem . . . 423
11.24.13alreadyThere . . . 424
11.24.14parseRadioboxes . . . 424
11.25Routines for paste-in areas . . . 425
11.25.1 parsePaste . . . 425
11.25.2 parsePastebutton . . . 427
11.25.3 parsePatch . . . 428
11.25.4 loadPatch . . . 430
11.26parsing routines for node types . . . 431
11.26.1 parseIfcond . . . 431
11.26.2 parseCondnode . . . 433
11.26.3 parseHasreturnto . . . 433
11.26.4 parseNewcond . . . 434
11.26.5 parseSetcond . . . 434
11.26.6 parseBeginItems . . . 434
11.26.7 parseItem . . . 435
11.26.8 parseMitem . . . 436
11.26.9 parseVerbatim . . . 436
11.26.10parseInputPix . . . 437

11.26.11 parseCenterline . . . 438
11.26.12 parseCommand . . . 438
11.26.13 parseButton . . . 439
11.26.14 parseSpadcommand . . . 440
11.26.15 parseSpadsrc . . . 440
11.26.16 parseEnv . . . 441
11.26.17 parseValue1 . . . 442
11.26.18 parseValue2 . . . 442
11.26.19 parseTable . . . 443
11.26.20 parseBox . . . 444
11.26.21 parseMbox . . . 444
11.26.22 parseFree . . . 445
11.26.23 parseHelp . . . 445
11.27 Reading bitmaps . . . 446
11.27.1 HTReadBitmapFile . . . 446
11.27.2 readHot . . . 448
11.27.3 readWandH . . . 448
11.27.4 insertImageStruct . . . 449
11.28 Scrollbar handling routines . . . 449
11.28.1 makeScrollBarWindows . . . 450
11.28.2 drawScroller3DEffects . . . 451
11.28.3 showScrollBars . . . 452
11.28.4 moveScroller . . . 453
11.28.5 drawScrollLines . . . 453
11.28.6 calculateScrollBarMeasures . . . 454
11.28.7 linkScrollBars . . . 455
11.28.8 scrollUp . . . 456
11.28.9 scrollUpPage . . . 456
11.28.10 scrollToFirstPage . . . 457
11.28.11 scrollDown . . . 457
11.28.12 scrollDownPage . . . 458
11.28.13 scrollScroller . . . 458
11.28.14 hideScrollBars . . . 459
11.28.15 getScrollBarMinimumSize . . . 459
11.28.16 h . . . 459
11.28.17 changeWindowBackgroundPixmap . . . 460
11.29 Display text object . . . 460
11.29.1 showText . . . 460
11.29.2 showLink . . . 465
11.29.3 showPaste . . . 466
11.29.4 showPastebutton . . . 466
11.29.5 showInput . . . 467
11.29.6 showSimpleBox . . . 467
11.29.7 showSpadcommand . . . 468
11.29.8 showImage . . . 468
11.30 Axiom communication interface . . . 470

11.30.1 issueSpadcommand . . . 470
11.30.2 sendPile . . . 470
11.30.3 issueDependentCommands . . . 471
11.30.4 markAsExecuted . . . 472
11.30.5 startUserBuffer . . . 472
11.30.6 clearExecutionMarks . . . 473
11.30.7 acceptMenuConnection . . . 474
11.30.8 acceptMenuServerConnection . . . 474
11.30.9 printToString . . . 476
11.30.10 printToString1 . . . 476
11.30.11 issueServerCommand . . . 480
11.30.12 issueServerpaste . . . 481
11.30.13 issueUnixcommand . . . 482
11.30.14 issueUnixlink . . . 482
11.30.15 issueUnixpaste . . . 483
11.30.16 serviceSessionSocket . . . 483
11.30.17 switchFrames . . . 483
11.30.18 sendLispCommand . . . 484
11.30.19 escapeString . . . 484
11.30.20 unescapeString . . . 484
11.30.21 closeClient . . . 485
11.30.22 printSourceToString . . . 485
11.30.23 printSourceToString1 . . . 486
11.31 Produce titlebar . . . 493
11.31.1 makeTitleBarWindows . . . 493
11.31.2 showTitleBar . . . 494
11.31.3 linkTitleBarWindows . . . 495
11.31.4 readTitleBarImages . . . 496
11.31.5 getTitleBarMinimumSize . . . 496
11.31.6 main . . . 497

12 The htsearch script **499**

13 The presea script **501**
13.1 token.h . . . 502

14 The Bitmaps **507**
14.1 ht_icon . . . 507
14.2 exit.bitmap . . . 507
14.3 help2.bitmap . . . 508
14.4 return3.bitmap . . . 509
14.5 up3.bitmap . . . 509
14.6 noop.bitmap . . . 510
14.7 exit3d.bitmap . . . 511
14.8 help3d.bitmap . . . 511
14.9 home3d.bitmap . . . 512

14.10up3d.bitmap 512
14.11noop3d.bitmap 513

Volume 7.1: Axiom Hyperdoc

1 Introduction **1**
1.1 Setting up the Hyperdoc fonts and colors 1

2 Release Notes **3**
2.1 releasenotes.ht 3
2.1.1 What is new in Axiom 3
2.1.2 Online Information 5
2.1.3 August 2014 Release Notes 6
2.1.4 May 2012 Release Notes 15
2.1.5 March 2012 Release Notes 17
2.1.6 January 2012 Release Notes 19
2.1.7 November 2011 Release Notes 22
2.1.8 September 2011 Release Notes 25
2.1.9 July 2011 Release Notes 27
2.1.10 May 2011 Release Notes 28
2.1.11 March 2011 Release Notes 31
2.1.12 January 2011 Release Notes 33
2.1.13 November 2010 Release Notes 35
2.1.14 September 2010 Release Notes 37
2.1.15 July 2010 Release Notes 40
2.1.16 May 2010 Release Notes 43
2.1.17 March 2010 Release Notes 47
2.1.18 January 2010 Release Notes 50
2.1.19 November 2009 Release Notes 52
2.1.20 September 2009 Release Notes 54
2.1.21 July 2009 Release Notes 56
2.1.22 May 2009 Release Notes 58
2.1.23 March 2009 Release Notes 63
2.1.24 January 2009 Release Notes 68
2.1.25 November 23, 2008 Release Notes 73
2.1.26 September 23, 2008 Release Notes 74
2.1.27 July 23, 2008 Release Notes 78
2.1.28 May 27, 2008 Release Notes 81
2.1.29 March 25, 2008 Release Notes 82
2.1.30 January 25, 2008 Release Notes 85
2.1.31 November 23, 2007 Release Notes 90
2.1.32 Feature Complete Release Feb 2005 94

3 Special hyperdoc pages **97**
3.1 util.ht 97
3.1.1 Names of software and facilities 97
3.1.2 Special hooks to Unix 97
3.1.3 HyperDoc menu macros 98

3.1.4 Bitmaps and bitmap manipulation macros . . . 99
3.1.5 HyperDoc button objects . . . 99
3.1.6 Standard HyperDoc button configurations . . . 100
3.1.7 HyperDoc graphics macros . . . 100
3.1.8 TeX and LaTeX compatibility macros . . . 101
3.1.9 Book and .ht page macros . . . 103
3.1.10 Browse macros . . . 105
3.1.11 Support for output and graph paste-ins . . . 106
3.1.12 Hook for including a local menu item on the rootpage . . . 106
3.1.13 Not Connected to Axiom . . . 107
3.1.14 Do You Really Want to Exit? . . . 107
3.1.15 Missing Page . . . 107
3.1.16 Something is Wrong . . . 108
3.1.17 Sorry! . . . 108

4 Hyperdoc pages **109**
4.1 rootpage.ht . . . 109
4.1.1 Axiom HyperDoc Top Level . . . 109
4.1.2 Axiom – The Scientific Computation System . . . 111
4.1.3 System Commands . . . 112
4.1.4 Axiom Examples . . . 112
4.1.5 Axiom Reference . . . 114
4.1.6 NAG Documentation . . . 117
4.2 algebra.ht . . . 123
4.2.1 Abstract Algebra . . . 123
4.2.2 Number Theory . . . 124
4.3 alist.ht . . . 125
4.3.1 AssociationList . . . 125
4.4 array1.ht . . . 131
4.4.1 OneDimensionalArray . . . 131
4.5 array2.ht . . . 136
4.5.1 TwoDimensionalArray . . . 136
4.6 basic.ht . . . 147
4.6.1 Basic Commands . . . 147
4.6.2 Calculus . . . 148
4.7 bbtree.ht . . . 149
4.7.1 BalancedBinaryTree . . . 149
4.8 binary.ht . . . 155
4.8.1 BinaryExpansion . . . 155
4.9 bmcat.ht . . . 159
4.9.1 Bit Map Catalog . . . 159
4.10 bop.ht . . . 161
4.10.1 BasicOperator . . . 161
4.11 bstree.ht . . . 170
4.11.1 BinarySearchTree . . . 170
4.12 card.ht . . . 176

4.12.1 CardinalNumber . . . 176
4.13 carten.ht . . . 186
4.13.1 CartesianTensor . . . 186
4.14 cclass.ht . . . 210
4.14.1 CharacterClass . . . 210
4.15 char.ht . . . 217
4.15.1 Character . . . 217
4.15.2 CliffordAlgebra . . . 223
4.15.3 The Complex Numbers as a Clifford Algebra . . . 225
4.15.4 The Quaternion Numbers as a Clifford Algebra . . . 229
4.15.5 The Exterior Algebra on a Three Space . . . 234
4.15.6 The Dirac Spin Algebra . . . 240
4.16 complex.ht . . . 244
4.16.1 Complex . . . 244
4.17 contfrac.ht . . . 252
4.17.1 ContinuedFraction . . . 252
4.18 cphelp.ht . . . 267
4.18.1 Control Panel Bits . . . 267
4.19 cycles.ht . . . 268
4.19.1 CycleIndicators . . . 268
4.20 coverex.ht . . . 292
4.20.1 Examples Of Axiom Commands . . . 292
4.20.2 Differentiation . . . 293
4.20.3 Integration . . . 298
4.20.4 Laplace Transforms . . . 305
4.20.5 Limits . . . 308
4.20.6 Matrices . . . 314
4.20.7 2-D Graphics . . . 322
4.20.8 3-D Graphics . . . 324
4.20.9 Series . . . 326
4.20.10 Summations . . . 331
4.21 decimal.ht . . . 337
4.21.1 Decimal Expansion . . . 337
4.22 derham.ht . . . 341
4.22.1 DeRhamComplex . . . 341
4.23 dfloat.ht . . . 357
4.23.1 DoubleFloat . . . 357
4.24 dmp.ht . . . 363
4.24.1 DistributedMultivariatePoly . . . 363
4.25 eq.ht . . . 368
4.25.1 Equation . . . 368
4.26 eqtbl.ht . . . 374
4.26.1 EqTable . . . 374
4.27 evalex.ht . . . 377
4.27.1 Example of Standard Evaluation . . . 377
4.27.2 Example of Standard Evaluation . . . 378

4.28 exdiff.ht . . . 380
4.28.1 Computing Derivatives . . . 380
4.28.2 Derivatives of Functions of Several Variables . . . 381
4.28.3 Derivatives of Higher Order . . . 383
4.28.4 Multiple Derivatives I . . . 384
4.28.5 Multiple Derivatives II . . . 386
4.28.6 Derivatives of Functions Involving Formal Integrals . . . 387
4.28.7 Exit . . . 389
4.29 exlap.ht . . . 392
4.29.1 Laplace transform with a single pole . . . 392
4.29.2 Laplace transform of a trigonometric function . . . 393
4.29.3 Laplace transform requiring a definite integration . . . 394
4.29.4 Laplace transform of exponentials . . . 395
4.29.5 Laplace transform of an exponential integral . . . 396
4.29.6 Laplace transform of special functions . . . 397
4.30 exint.ht . . . 398
4.30.1 Integral of a Rational Function . . . 398
4.30.2 Integral of a Rational Function with a Real Parameter . . . 401
4.30.3 Integral of a Rational Function with a Complex Parameter . . . 402
4.30.4 Two Similar Integrands Producing Very Different Results . . . 403
4.30.5 An Integral Which Does Not Exist . . . 405
4.30.6 A Trigonometric Function of a Quadratic . . . 406
4.30.7 Integrating a Function with a Hidden Algebraic Relation . . . 407
4.30.8 Details for integrating a function with a Hidden Algebraic Relation . . . 408
4.30.9 An Integral Involving a Root of a Transcendental Function . . . 409
4.30.10 An Integral of a Non-elementary Function . . . 410
4.31 exlimit.ht . . . 411
4.31.1 Computing Limits . . . 411
4.31.2 Limits of Functions with Parameters . . . 412
4.31.3 One-sided Limits . . . 413
4.31.4 Two-sided Limits . . . 415
4.31.5 Limits at Infinity . . . 416
4.31.6 Real Limits vs. Complex Limits . . . 418
4.31.7 Complex Limits at Infinity . . . 419
4.32 exmatrix.ht . . . 421
4.32.1 Basic Arithmetic Operations on Matrices . . . 421
4.32.2 Constructing new Matrices . . . 425
4.32.3 Trace of a Matrix . . . 429
4.32.4 Determinant of a Matrix . . . 430
4.32.5 Inverse of a Matrix . . . 431
4.32.6 Rank of a Matrix . . . 432
4.33 expr.ht . . . 433
4.33.1 Expression . . . 433
4.34 explot2d.ht . . . 445
4.34.1 Plotting Functions of One Variable . . . 445
4.34.2 Plotting Parametric Curves . . . 446

4.34.3 Plotting Using Polar Coordinates . . . 447
4.34.4 Plotting Plane Algebraic Curves . . . 448
4.35 explot3d.ht . . . 449
4.35.1 Plotting Functions of Two Variables . . . 449
4.35.2 Plotting Parametric Surfaces . . . 450
4.35.3 Plotting Parametric Curves . . . 451
4.36 expose.ht . . . 452
4.36.1 Exposure . . . 452
4.36.2 System Defined Exposure Groups . . . 453
4.36.3 What is an Exposure Group? . . . 453
4.36.4 Details on Exposure . . . 454
4.37 exseries.ht . . . 455
4.37.1 Converting Expressions to Series . . . 455
4.37.2 Manipulating Power Series . . . 457
4.37.3 Functions on Power Series . . . 458
4.37.4 Substituting Numerical Values in Power Series . . . 460
4.38 exsum.ht . . . 462
4.38.1 Summing the Entries of a List I . . . 462
4.38.2 Summing the Entries of a List II . . . 463
4.38.3 Approximating e . . . 464
4.38.4 Closed Form Summations . . . 465
4.38.5 Sums of Cubes . . . 467
4.38.6 Sums of Polynomials . . . 468
4.38.7 Sums of General Functions . . . 469
4.38.8 Infinite Sums . . . 470
4.39 farray.ht . . . 472
4.39.1 FlexibleArray . . . 472
4.40 file.ht . . . 480
4.40.1 File . . . 480
4.41 float.ht . . . 487
4.41.1 Float . . . 487
4.41.2 Introduction to Float . . . 488
4.41.3 Conversion Functions . . . 491
4.41.4 Output Functions . . . 499
4.41.5 An Example: Determinant of a Hilbert Matrix . . . 503
4.42 fname.ht . . . 509
4.42.1 FileName . . . 509
4.43 fr.ht . . . 517
4.43.1 Factored . . . 517
4.43.2 Decomposing Factored Objects . . . 519
4.43.3 Expanding Factored Objects . . . 523
4.43.4 Arithmetic with Factored Objects . . . 525
4.43.5 Creating New Factored Objects . . . 532
4.43.6 Factored Objects with Variables . . . 536
4.44 fr2.ht . . . 539
4.44.1 FactoredFunctions2 . . . 539

4.45 frac.ht . . . 543
4.45.1 Fraction . . . 543
4.46 fparfrac.ht . . . 550
4.46.1 FullPartialFracExpansion . . . 550
4.47 function.ht . . . 560
4.47.1 Functions in Axiom . . . 560
4.47.2 Rational Functions . . . 562
4.47.3 Algebraic Functions . . . 565
4.47.4 Elementary Functions . . . 568
4.47.5 Simplification . . . 570
4.48 gbf.ht . . . 577
4.48.1 GroebnerFactorizationPkg . . . 577
4.49 gloss.ht . . . 582
4.49.1 Glossary . . . 582
4.50 graphics.ht . . . 602
4.50.1 Graphics . . . 602
4.50.2 Graphics Examples . . . 603
4.50.3 Assorted Graphics Examples . . . 604
4.50.4 Three Dimensional Graphics . . . 607
4.50.5 Functions of One Variable . . . 612
4.50.6 Parametric Curves . . . 614
4.50.7 Polar Coordinates . . . 616
4.50.8 Implicit Curves . . . 618
4.50.9 Lists of Points . . . 622
4.50.10 Three Dimensional Graphing . . . 632
4.50.11 Functions of Two Variables . . . 633
4.50.12 Parametric Space Curves . . . 636
4.50.13 Parametric Tube Plots . . . 639
4.50.14 Parametric Surfaces . . . 642
4.50.15 Building 3D Objects . . . 645
4.50.16 Two Dimensional Graphics . . . 649
4.50.17 Functions of One Variable . . . 651
4.50.18 Parametric Curves . . . 654
4.50.19 Polar Coordinates . . . 657
4.50.20 Implicit Curves . . . 659
4.50.21 Lists of Points . . . 661
4.50.22 Stand-alone Viewport . . . 671
4.51 grpthry.ht . . . 674
4.51.1 Group Theory . . . 674
4.51.2 Representations of A_6 A6 . . . 675
4.51.3 Representation Theory . . . 693
4.51.4 Group Theory . . . 695
4.52 gstbl.ht . . . 697
4.52.1 GeneralSparseTable . . . 697
4.53 heap.ht . . . 701
4.53.1 Heap . . . 701

4.54 hexadec.ht . . . 703
4.54.1 HexadecimalExpansion . . . 703
4.55 int.ht . . . 707
4.55.1 Integer . . . 707
4.55.2 Basic Functions . . . 709
4.55.3 Primes and Factorization . . . 722
4.55.4 Some Number Theoretic Functions . . . 726
4.56 intheory.ht . . . 732
4.56.1 IntegerNumberTheoryFunctions . . . 732
4.57 kafile.ht . . . 744
4.57.1 KeyedAccessFile . . . 744
4.58 kernel.ht . . . 754
4.58.1 Kernel . . . 754
4.59 lazm3pk.ht . . . 763
4.59.1 LazardSetSolvingPackage . . . 763
4.60 lexp.ht . . . 787
4.60.1 LieExponentials . . . 787
4.61 lextripk.ht . . . 793
4.61.1 LexTriangularPackage . . . 793
4.62 lib.ht . . . 846
4.62.1 Library . . . 846
4.63 link.ht . . . 850
4.63.1 The Axiom Link to NAG Software . . . 850
4.63.2 Use of the Link from HyperDoc . . . 850
4.63.3 C02 Zeros of Polynomials . . . 852
4.63.4 C05 Roots of One or More Transcendental Equations . . . 853
4.63.5 C06 Summation of Series . . . 854
4.63.6 D01 Quadrature . . . 856
4.63.7 D02 Ordinary Differential Equations . . . 858
4.63.8 D03 Partial Differential Equations . . . 860
4.63.9 E01 Interpolation . . . 861
4.63.10 E02 Curve and Surface Fitting . . . 863
4.63.11 E04 Minimizing or Maximizing a Function . . . 865
4.63.12 F01 Matrix Operations - Including Inversion . . . 867
4.63.13 F02 Eigenvalues and Eigenvectors . . . 869
4.63.14 F04 Simultaneous Linear Equations . . . 871
4.63.15 F07 Linear Equations (LAPACK) . . . 873
4.63.16 S – Approximations of Special Functions . . . 874
4.64 list.ht . . . 877
4.64.1 List . . . 877
4.64.2 Creating Lists . . . 879
4.64.3 Accessing List Elements . . . 882
4.64.4 Changing List Elements . . . 888
4.64.5 Other Functions . . . 892
4.64.6 Dot, Dot . . . 896
4.65 lodo.ht . . . 898

4.65.1 LinearOrdinaryDifferentialOperator . . . 898
4.65.2 Differential Operators with Series Coefficients . . . 899
4.66 lodo1.ht . . . 909
4.66.1 LinearOrdinaryDifferentialOperator1 . . . 909
4.66.2 Differential Operators with Rational Function Coefficients . . . 910
4.67 lodo2.ht . . . 920
4.67.1 LinearOrdinaryDifferentialOperator2 . . . 920
4.67.2 Differential Operators with Constant Coefficients . . . 922
4.67.3 Differential Operators with Matrix Coefficients Operating on Vectors . 928
4.68 lpoly.ht . . . 936
4.68.1 LiePolynomial . . . 936
4.69 lword.ht . . . 948
4.69.1 LyndonWord . . . 948
4.70 magma.ht . . . 958
4.70.1 Magma . . . 958
4.71 man0.ht . . . 967
4.71.1 Reference Search . . . 967
4.71.2 Lisp Functions . . . 968
4.71.3 Axiom Browser . . . 976
4.71.4 The Hyperdoc Browse Facility . . . 977
4.72 mapping.ht . . . 978
4.72.1 Domain **Mapping(T,S,...)** . . . 978
4.72.2 Domain Constructor **Mapping** . . . 978
4.73 mappkg1.ht . . . 979
4.73.1 MappingPackage1 . . . 979
4.74 mset.ht . . . 992
4.74.1 MultiSet . . . 992
4.75 matrix.ht . . . 998
4.75.1 Matrix . . . 998
4.75.2 Creating Matrices . . . 999
4.75.3 Operations on Matrices . . . 1011
4.76 mkfunc.ht . . . 1021
4.76.1 MakeFunction . . . 1021
4.77 mpoly.ht . . . 1027
4.77.1 MultivariatePolynomial . . . 1027
4.78 newuser.ht . . . 1033
4.78.1 No More Help :-(. . . 1033
4.78.2 You Tried It! . . . 1033
4.79 none.ht . . . 1034
4.79.1 None . . . 1034
4.80 numbers.ht . . . 1036
4.80.1 Axiom Number Types . . . 1036
4.80.2 Fraction . . . 1038
4.80.3 Rational Number . . . 1040
4.80.4 Integers . . . 1043
4.80.5 Integer Examples . . . 1048

4.80.6 Integer Example Proof . . . 1050
4.80.7 Integer Problems . . . 1051
4.80.8 Integer Problem Proof . . . 1052
4.80.9 Solution to Problem #1 . . . 1053
4.80.10 Solution to Problem #2 . . . 1057
4.81 oct.ht . . . 1059
4.81.1 Octonion . . . 1059
4.82 odpol.ht . . . 1068
4.82.1 OrderlyDifferentialPolynomial . . . 1068
4.83 op.ht . . . 1085
4.83.1 Operator . . . 1085
4.84 ovar.ht . . . 1096
4.84.1 OrderedVariableList . . . 1096
4.85 perman.ht . . . 1099
4.85.1 Permanent . . . 1099
4.86 pfr.ht . . . 1102
4.86.1 PartialFraction . . . 1102
4.87 poly.ht . . . 1109
4.87.1 Polynomials . . . 1109
4.87.2 The Specific Polynomial Types . . . 1110
4.87.3 Basic Operations On Polynomials . . . 1111
4.87.4 Polynomial Evaluation and Substitution . . . 1119
4.87.5 Greatest Common Divisors, Resultants, and Discriminants . . . 1122
4.87.6 Roots of Polynomials . . . 1124
4.88 poly1.ht . . . 1125
4.88.1 Polynomial . . . 1125
4.89 quat.ht . . . 1147
4.89.1 Quaternion . . . 1147
4.90 radix.ht . . . 1153
4.90.1 RadixExpansion . . . 1153
4.91 reclos.ht . . . 1161
4.91.1 RealClosure . . . 1161
4.92 record.ht . . . 1192
4.92.1 Domain **Record(a:A,...,b:B)** . . . 1192
4.92.2 Domain Constructor **Record** . . . 1193
4.93 regset.ht . . . 1194
4.93.1 RegularTriangularSet . . . 1194
4.94 roman.ht . . . 1221
4.94.1 RomanNumeral . . . 1221
4.95 seg.ht . . . 1227
4.95.1 Segment . . . 1227
4.96 segbind.ht . . . 1232
4.96.1 SegmentBinding . . . 1232
4.97 set.ht . . . 1236
4.97.1 Set . . . 1236
4.98 sint.ht . . . 1245

4.98.1 SingleInteger . . . 1245
4.99 sqmatrix.ht . . . 1251
4.99.1 SquareMatrix . . . 1251
4.100sregset.ht . . . 1255
4.100.1 SquareFreeRegularTriangularSet . . . 1255
4.101stbl.ht . . . 1267
4.101.1 SparseTable . . . 1267
4.102stream.ht . . . 1271
4.102.1 Stream . . . 1271
4.103string.ht . . . 1277
4.103.1 String . . . 1277
4.104strtbl.ht . . . 1292
4.104.1 StringTable . . . 1292
4.105symbol.ht . . . 1294
4.105.1 Symbol . . . 1294
4.106table.ht . . . 1305
4.106.1 Table . . . 1305
4.107textfile.ht . . . 1314
4.107.1 TextFile . . . 1314
4.108topics.ht . . . 1320
4.108.1 Axiom Topics . . . 1320
4.108.2 Solving Equations . . . 1321
4.108.3 Linear Algebra . . . 1322
4.108.4 Calculus . . . 1324
4.109type.ht . . . 1325
4.109.1 Category **Type** . . . 1325
4.110union.ht . . . 1325
4.110.1 Domain **Union(a:A,...,b:B)** . . . 1325
4.110.2 Domain Constructor **Union** . . . 1326
4.110.3 Domain **Union(A,...,B)** . . . 1326
4.110.4 Domain Constructor **Union** . . . 1327
4.111uniseg.ht . . . 1328
4.111.1 UniversalSegment . . . 1328
4.112up.ht . . . 1333
4.112.1 UnivariatePolynomial . . . 1333
4.113oreup.ht . . . 1350
4.113.1 UnivariateSkewPolynomial . . . 1350
4.114vector.ht . . . 1357
4.114.1 Vector . . . 1357
4.115void.ht . . . 1363
4.115.1 Void . . . 1363
4.116wutset.ht . . . 1366
4.116.1 WuWenTsunTriangularSet . . . 1366
4.117xmpexp.ht . . . 1374
4.117.1 Some Examples of Domains and Packages . . . 1374
4.118xpbwpoly.ht . . . 1379

4.118.1 XPBWPolynomial . . . 1379
4.119xpoly.ht . . . 1400
4.119.1 XPolynomial . . . 1400
4.120xpr.ht . . . 1408
4.120.1 XPolynomialRing . . . 1408
4.121zdsolve.ht . . . 1417
4.121.1 ZeroDimensionalSolvePackage . . . 1417
4.122zlindep.ht . . . 1465
4.122.1 IntegerLinearDependence . . . 1465

5 Users Guide Pages (ug.ht) 1471
5.0.2 Users Guide . . . 1471

6 Users Guide Chapter 0 (ug00.ht) 1475
6.0.3 What's New for May 2008 . . . 1475
6.0.4 New polynomial domains and algorithms . . . 1476
6.0.5 Enhancements to HyperDoc and Graphics . . . 1478
6.0.6 Enhancements to NAGLink . . . 1478
6.0.7 Enhancements to the Lisp system . . . 1479

7 Users Guide Chapter 1 (ug01.ht) 1485
7.0.8 An Overview of Axiom . . . 1486
7.0.9 Starting Up and Winding Down . . . 1488
7.0.10 Clef . . . 1490
7.0.11 Typographic Conventions . . . 1492
7.0.12 The Axiom Language . . . 1493
7.0.13 Arithmetic Expressions . . . 1495
7.0.14 Previous Results . . . 1497
7.0.15 Some Types . . . 1500
7.0.16 Symbols, Variables, Assignments, and Declarations . . . 1503
7.0.17 Conversion . . . 1510
7.0.18 Calling Functions . . . 1512
7.0.19 Some Predefined Macros . . . 1515
7.0.20 Long Lines . . . 1516
7.0.21 Comments . . . 1517
7.0.22 Graphics . . . 1519
7.0.23 Numbers . . . 1521
7.0.24 Data Structures . . . 1539
7.0.25 Expanding to Higher Dimensions . . . 1555
7.0.26 Writing Your Own Functions . . . 1560
7.0.27 Polynomials . . . 1572
7.0.28 Limits . . . 1576
7.0.29 Series . . . 1581
7.0.30 Derivatives . . . 1588
7.0.31 Integration . . . 1595
7.0.32 Differential Equations . . . 1603

7.0.33 Solution of Equations 1610
7.0.34 System Commands 1615

8 Users Guide Chapter 2 (ug02.ht) 1623
8.0.35 Using Types and Modes 1623
8.0.36 The Basic Idea 1625
8.0.37 Domain Constructors 1629
8.0.38 Writing Types and Modes 1639
8.0.39 Types with No Arguments 1642
8.0.40 Types with One Argument 1644
8.0.41 Types with More Than One Argument 1648
8.0.42 Modes 1649
8.0.43 Abbreviations 1651
8.0.44 Declarations 1654
8.0.45 Records 1661
8.0.46 Unions 1669
8.0.47 Unions Without Selectors 1670
8.0.48 Unions With Selectors 1678
8.0.49 The "Any" Domain 1682
8.0.50 Conversion 1685
8.0.51 Subdomains Again 1693
8.0.52 Package Calling and Target Types 1700
8.0.53 Resolving Types 1709
8.0.54 Exposing Domains and Packages 1713
8.0.55 Commands for Snooping 1717

9 Users Guide Chapter 3 (ug03.ht) 1723
9.0.56 Using Hyperdoc 1723
9.0.57 Headings 1725
9.0.58 Key Definitions 1727
9.0.59 Scroll Bars 1728
9.0.60 Input Areas 1730
9.0.61 Radio Buttons and Toggles 1732
9.0.62 Search Strings 1734
9.0.63 Logical Searches 1736
9.0.64 Example Pages 1737
9.0.65 X Window Resources for Hyperdoc 1739

10 Users Guide Chapter 4 (ug04.ht) 1741
10.0.66 Input Files and Output Styles 1741
10.0.67 Input Files 1743
10.0.68 The .axiom.input File 1745
10.0.69 Common Features of Using Output Formats 1746
10.0.70 Monospace 2D Mathematical Format 1750
10.0.71 TeX Format 1753
10.0.72 IBM Script Formula Format 1755

10.0.73 FORTRAN Format . . . 1756
10.0.74 HTML Format . . . 1765
10.0.75 MathML Format . . . 1766

11 Users Guide Chapter 5 (ug05.ht) 1767
11.0.76 Introduction to the Axiom Interactive Language . . . 1767
11.0.77 Immediate and Delayed Assignments . . . 1769
11.0.78 Blocks . . . 1777
11.0.79 if-then-else . . . 1786
11.0.80 Loops . . . 1789
11.0.81 Compiling vs. Interpreting Loops . . . 1791
11.0.82 return in Loops . . . 1792
11.0.83 break in Loops . . . 1796
11.0.84 break vs. => in Loop Bodies . . . 1800
11.0.85 More Examples of break . . . 1801
11.0.86 iterate in Loops . . . 1809
11.0.87 while Loops . . . 1811
11.0.88 for Loops . . . 1818
11.0.89 for i in n..m repeat . . . 1819
11.0.90 for i in n..m by s repeat . . . 1823
11.0.91 for i in n.. repeat . . . 1825
11.0.92 for x in l repeat . . . 1827
11.0.93 "Such that" Predicates . . . 1830
11.0.94 Parallel Iteration . . . 1832
11.0.95 Creating Lists and Streams with Iterators . . . 1838
11.0.96 An Example: Streams of Primes . . . 1845

12 Users Guide Chapter 6 (ug06.ht) 1853
12.0.97 User-Defined Functions, Macros and Rules . . . 1854
12.0.98 Functions vs. Macros . . . 1857
12.0.99 Macros . . . 1859
12.0.100 Introduction to Functions . . . 1867
12.0.101 Declaring the Type of Functions . . . 1870
12.0.102 One-Line Functions . . . 1874
12.0.103 Declared vs. Undeclared Functions . . . 1879
12.0.104 Functions vs. Operations . . . 1883
12.0.105 Delayed Assignments vs. Functions with No Arguments . . . 1885
12.0.106 How Axiom Determines What Function to Use . . . 1888
12.0.107 Compiling vs. Interpreting . . . 1893
12.0.108 Piece-Wise Function Definitions . . . 1896
12.0.109 A Basic Example . . . 1897
12.0.110 Picking Up the Pieces . . . 1904
12.0.111 Predicates . . . 1910
12.0.112 Caching Previously Computed Results . . . 1915
12.0.113 Recurrence Relations . . . 1918
12.0.114 Making Functions from Objects . . . 1924

12.0.115 Functions Defined with Blocks . . . 1933
12.0.116 Free and Local Variables . . . 1941
12.0.117 Anonymous Functions . . . 1956
12.0.118 Some Examples . . . 1958
12.0.119 Declaring Anonymous Functions . . . 1963
12.0.120 Example: A Database . . . 1968
12.0.121 Example: A Famous Triangle . . . 1975
12.0.122 Example: Testing for Palindromes . . . 1981
12.0.123 Rules and Pattern Matching . . . 1986

13 Users Guide Chapter 7 (ug07.ht) 2003
13.0.124 Graphics . . . 2004
13.0.125 Two-Dimensional Graphics . . . 2005
13.0.126 Plotting Two-Dimensional Functions of One Variable . . . 2007
13.0.127 Plotting 2D Parametric Plane Curves . . . 2010
13.0.128 Plotting Plane Algebraic Curves . . . 2014
13.0.129 Two-Dimensional Options . . . 2016
13.0.130 Color . . . 2022
13.0.131 Palette . . . 2024
13.0.132 Two-Dimensional Control-Panel . . . 2027
13.0.133 Operations for Two-Dimensional Graphics . . . 2030
13.0.134 Addendum: Building Two-Dimensional Graphs . . . 2034
13.0.135 Addendum: Appending a Graph to a Viewport Window Containing a Graph . . . 2053
13.0.136 Three-Dimensional Graphics . . . 2056
13.0.137 Plotting Three-Dimensional Functions of Two Variables . . . 2058
13.0.138 Plotting Three-Dimensional Parametric Space Curves . . . 2061
13.0.139 Plotting 3D Parametric Surfaces . . . 2064
13.0.140 Three-Dimensional Options . . . 2068
13.0.141 The makeObject Command . . . 2078
13.0.142 Building 3D Objects From Primitives . . . 2081
13.0.143 Coordinate System Transformations . . . 2093
13.0.144 Three-Dimensional Clipping . . . 2100
13.0.145 Three-Dimensional Control-Panel . . . 2102
13.0.146 Operations for Three-Dimensional Graphics . . . 2108
13.0.147 Customization using .Xdefaults . . . 2114

14 Users Guide Chapter 8 (ug08.ht) 2117
14.0.148 Advanced Problem Solving . . . 2117
14.0.149 Numeric Functions . . . 2119
14.0.150 Polynomial Factorization . . . 2140
14.0.151 Integer and Rational Number Coefficients . . . 2141
14.0.152 Finite Field Coefficients . . . 2143
14.0.153 Simple Algebraic Extension Field Coefficients . . . 2145
14.0.154 Factoring Rational Functions . . . 2150
14.0.155 Manipulating Symbolic Roots of a Polynomial . . . 2152

14.0.156 Using a Single Root of a Polynomial . . . 2153
14.0.157 Using All Roots of a Polynomial . . . 2158
14.0.158 Computation of Eigenvalues and Eigenvectors . . . 2163
14.0.159 Solution of Linear and Polynomial Equations . . . 2171
14.0.160 Solution of Systems of Linear Equations . . . 2172
14.0.161 Solution of a Single Polynomial Equation . . . 2176
14.0.162 Solution of Systems of Polynomial Equations . . . 2181
14.0.163 Limits . . . 2186
14.0.164 Laplace Transforms . . . 2194
14.0.165 Integration . . . 2198
14.0.166 Working with Power Series . . . 2206
14.0.167 Creation of Power Series . . . 2208
14.0.168 Coefficients of Power Series . . . 2214
14.0.169 Power Series Arithmetic . . . 2217
14.0.170 Functions on Power Series . . . 2221
14.0.171 Converting to Power Series . . . 2229
14.0.172 Power Series from Formulas . . . 2237
14.0.173 Substituting Numerical Values in Power Series . . . 2243
14.0.174 Example: Bernoulli Polynomials and Sums of Powers . . . 2245
14.0.175 Solution of Differential Equations . . . 2254
14.0.176 Closed-Form Solutions of Linear Differential Equations . . . 2255
14.0.177 Closed-Form Solutions of Non-Linear DEs . . . 2263
14.0.178 Power Series Solutions of Differential Equations . . . 2273
14.0.179 Finite Fields . . . 2278
14.0.180 Modular Arithmetic and Prime Fields . . . 2280
14.0.181 Extensions of Finite Fields . . . 2289
14.0.182 Irreducible Mod Polynomial Representations . . . 2292
14.0.183 Cyclic Group Representations . . . 2300
14.0.184 Normal Basis Representations . . . 2307
14.0.185 Conversion Operations for Finite Fields . . . 2314
14.0.186 Utility Operations for Finite Fields . . . 2322
14.0.187 Primary Decomposition of Ideals . . . 2338
14.0.188 Computation of Galois Groups . . . 2346
14.0.189 Non-Associative Algebras and Genetic Laws . . . 2365

15 Users Guide Chapter 10 (ug10.ht) 2377
15.0.190 Interactive Programming . . . 2377
15.0.191 Drawing Ribbons Interactively . . . 2379
15.0.192 A Ribbon Program . . . 2384
15.0.193 Coloring and Positioning Ribbons . . . 2387
15.0.194 Points, Lines, and Curves . . . 2389
15.0.195 A Bouquet of Arrows . . . 2396
15.0.196 Drawing Complex Vector Fields . . . 2398
15.0.197 Drawing Complex Functions . . . 2403
15.0.198 Functions Producing Functions . . . 2407
15.0.199 Automatic Newton Iteration Formulas . . . 2409

16 Users Guide Chapter 11 (ug11.ht) 2419
16.0.200 Packages . . . 2419
16.0.201 Names, Abbreviations, and File Structure . . . 2422
16.0.202 Syntax . . . 2424
16.0.203 Abstract Datatypes . . . 2426
16.0.204 Capsules . . . 2428
16.0.205 Input Files vs. Packages . . . 2430
16.0.206 Compiling Packages . . . 2431
16.0.207 Parameters . . . 2435
16.0.208 Conditionals . . . 2438
16.0.209 Testing . . . 2441
16.0.210 How Packages Work . . . 2448

17 Users Guide Chapter 12 (ug12.ht) 2451
17.0.211 Categories . . . 2451
17.0.212 Definitions . . . 2453
17.0.213 Exports . . . 2456
17.0.214 Documentation . . . 2458
17.0.215 Hierarchies . . . 2460
17.0.216 Membership . . . 2462
17.0.217 Defaults . . . 2464
17.0.218 Axioms . . . 2466
17.0.219 Correctness . . . 2468
17.0.220 Attributes . . . 2469
17.0.221 Parameters . . . 2472
17.0.222 Conditionals . . . 2474
17.0.223 Anonymous Categories . . . 2476

18 Users Guide Chapter 13 (ug13.ht) 2479
18.0.224 Domains . . . 2479
18.0.225 Domains vs. Packages . . . 2481
18.0.226 Definitions . . . 2482
18.0.227 Category Assertions . . . 2485
18.0.228 A Demo . . . 2487
18.0.229 Browse . . . 2491
18.0.230 Representation . . . 2493
18.0.231 Multiple Representations . . . 2494
18.0.232 Add Domain . . . 2496
18.0.233 Defaults . . . 2497
18.0.234 Origins . . . 2499
18.0.235 Short Forms . . . 2501
18.0.236 Example 1: Clifford Algebra . . . 2502
18.0.237 Example 2: Building A Query Facility . . . 2505
18.0.238 A Little Query Language . . . 2507
18.0.239 The Database Constructor . . . 2510
18.0.240 Query Equations . . . 2513

18.0.241 DataLists . . . 2515
18.0.242 Index Cards . . . 2517
18.0.243 Creating a Database . . . 2518
18.0.244 Putting It All Together . . . 2519
18.0.245 Example Queries . . . 2521

19 Users Guide Chapter 14 (ug14.ht) 2533
19.0.246 Browse . . . 2533
19.0.247 The Front Page: Searching the Library . . . 2534
19.0.248 The Constructor Page . . . 2537
19.0.249 Constructor Page Buttons . . . 2539
19.0.250 Cross Reference . . . 2542
19.0.251 Views Of Constructors . . . 2546
19.0.252 Giving Parameters to Constructors . . . 2548
19.0.253 Miscellaneous Features of Browse . . . 2550
19.0.254 The Description Page for Operations . . . 2551
19.0.255 Views of Operations . . . 2553
19.0.256 Capitalization Convention . . . 2556

20 Users Guide Chapter 15 (ug15.ht) 2559
20.0.257 What's New in Axiom Version 2.0 . . . 2559
20.0.258 Important Things to Read First . . . 2560
20.0.259 The NAG Library Link . . . 2561
20.0.260 Interpreting NAG Documentation . . . 2562
20.0.261 Using the Link . . . 2565
20.0.262 Providing values for Argument Subprograms . . . 2569
20.0.263 General Fortran-generation utilities in Axiom . . . 2572
20.0.264 Some technical information . . . 2596
20.0.265 Interactive Front-end and Language . . . 2597
20.0.266 Library . . . 2599
20.0.267 HyperDoc . . . 2601
20.0.268 Documentation . . . 2603

21 Users Guide Chapter 16 (ug16.ht) 2605
21.0.269 Axiom System Commands . . . 2606
21.0.270 Introduction . . . 2608
21.0.271)abbreviation . . . 2610
21.0.272)boot . . . 2612
21.0.273)cd . . . 2614
21.0.274)close . . . 2616
21.0.275)clear . . . 2617
21.0.276)compile . . . 2620
21.0.277)display . . . 2623
21.0.278)edit . . . 2625
21.0.279)fin . . . 2627
21.0.280)frame . . . 2628

21.0.281)help . . . 2631
21.0.282)history . . . 2632
21.0.283)library . . . 2636
21.0.284)lisp . . . 2638
21.0.285)load . . . 2639
21.0.286)ltrace . . . 2640
21.0.287)pquit . . . 2641
21.0.288)quit . . . 2643
21.0.289)read . . . 2645
21.0.290)set . . . 2647
21.0.291)show . . . 2649
21.0.292)spool . . . 2651
21.0.293)synonym . . . 2652
21.0.294)system . . . 2654
21.0.295)trace . . . 2656
21.0.296)undo . . . 2662
21.0.297)what . . . 2664

22 Users Guide Chapter 21 (ug21.ht) 2667
22.0.298 Programs for Axiom Images . . . 2668
22.0.299 images1.input . . . 2670
22.0.300 images2.input . . . 2671
22.0.301 images3.input . . . 2672
22.0.302 images5.input . . . 2673
22.0.303 images6.input . . . 2675
22.0.304 images7.input . . . 2677
22.0.305 images8.input . . . 2679
22.0.306 conformal.input . . . 2680
22.0.307 tknot.input . . . 2684
22.0.308 ntube.input . . . 2685
22.0.309 lhtri.input . . . 2688
22.0.310 tetra.input . . . 2690
22.0.311 antoine.input . . . 2692
22.0.312 scherk.input . . . 2694

23 Hypertex Language Pages 2697
23.0.313 Creating Hyperdoc Pages . . . 2697
23.1 htxadvpage1.ht . . . 2697
23.1.1 Input Areas . . . 2697
23.1.2 HTXAdvPage1xPatch1 patch . . . 2699
23.1.3 HTXAdvPage1xPatch1A patch . . . 2699
23.1.4 HTXAdvPage1xPatch2 patch . . . 2699
23.1.5 HTXAdvPage1xPatch2A patch . . . 2700
23.2 htxadvpage2.ht . . . 2700
23.2.1 Radio buttons . . . 2700
23.3 htxadvpage3.ht . . . 2703

23.3.1 Macros . . . 2703
23.4 htxadvpage4.ht . . . 2704
23.4.1 Patch and Paste . . . 2704
23.4.2 patch1 patch . . . 2707
23.4.3 Patch1 patch . . . 2707
23.4.4 Patch2 patch . . . 2708
23.5 htxadvpage5.ht . . . 2708
23.5.1 Axiom paste-ins . . . 2708
23.6 htxadvpage6.ht . . . 2710
23.6.1 Miscellaneous . . . 2710
23.6.2 HTXAdvPage6xPatch1 patch . . . 2712
23.6.3 HTXAdvPage6xPatch1A patch . . . 2712
23.6.4 HTXAdvPage6xPatch2 patch . . . 2713
23.6.5 HTXAdvPage6xPatch2A patch . . . 2713
23.6.6 HTXAdvPage6xPatch3 patch . . . 2713
23.6.7 HTXAdvPage6xPatch3A patch . . . 2714
23.7 htxadvtoppage.ht . . . 2714
23.7.1 Advanced features in Hyperdoc . . . 2714
23.8 htxformatpage1.ht . . . 2715
23.8.1 Using the special characters . . . 2715
23.8.2 HTXFormatPage1xPatch1 patch . . . 2716
23.8.3 HTXFormatPage1xPatch2 patch . . . 2716
23.9 htxformatpage2.ht . . . 2717
23.9.1 Formatting without commands . . . 2717
23.9.2 HTXFormatPage2xPatch1 patch . . . 2718
23.9.3 HTXFormatPage2xPatch2 patch . . . 2719
23.9.4 HTXFormatPage2xPatch2A patch . . . 2719
23.9.5 HTXFormatPage2xPatch3 patch . . . 2719
23.9.6 HTXFormatPage2xPatch3A patch . . . 2720
23.9.7 HTXFormatPage2xPatch4 patch . . . 2720
23.9.8 HTXFormatPage2xPatch4A patch . . . 2721
23.10 htxformatpage3.ht . . . 2721
23.10.1 Using different fonts . . . 2721
23.10.2 HTXFormatPage3xPatch1 patch . . . 2723
23.10.3 HTXFormatPage3xPatch2 patch . . . 2723
23.10.4 HTXFormatPage3xPatch3 patch . . . 2724
23.10.5 HTXFormatPage3xPatch4 patch . . . 2724
23.11 htxformatpage4.ht . . . 2724
23.11.1 Indentation . . . 2724
23.11.2 HTXFormatPage4xPatch1 patch . . . 2727
23.11.3 HTXFormatPage4xPatch1A patch . . . 2727
23.11.4 HTXFormatPage4xPatch2 patch . . . 2727
23.11.5 HTXFormatPage4xPatch2A patch . . . 2727
23.11.6 HTXFormatPage4xPatch3 patch . . . 2728
23.11.7 HTXFormatPage4xPatch3A patch . . . 2728
23.11.8 HTXFormatPage4xPatch4 patch . . . 2728

23.11.9 HTXFormatPage4xPatch5 patch . . . 2729
23.11.10 HTXFormatPage4xPatch5A patch . . . 2729
23.12 htxformatpage5.ht . . . 2730
23.12.1 Creating Lists and Tables . . . 2730
23.12.2 HTXFormatPage5xPatch1 patch . . . 2732
23.12.3 HTXFormatPage5xPatch1A patch . . . 2733
23.12.4 HTXFormatPage5xPatch2 patch . . . 2733
23.12.5 HTXFormatPage5xPatch2A patch . . . 2734
23.12.6 HTXFormatPage5xPatch3 patch . . . 2734
23.12.7 HTXFormatPage5xPatch3A patch . . . 2735
23.13 htxformatpage6 . . . 2735
23.13.1 Boxes and Lines . . . 2735
23.13.2 HTXFormatPage6xPatch1 patch . . . 2736
23.13.3 HTXFormatPage6xPatch2 patch . . . 2736
23.14 htxformatpage7 . . . 2737
23.14.1 Micro-Spacing . . . 2737
23.14.2 HTXFormatPage7xPatch1 patch . . . 2738
23.14.3 HTXFormatPage7xPatch2 patch . . . 2739
23.14.4 HTXFormatPage7xPatch2A patch . . . 2739
23.14.5 HTXFormatPage7xPatch3 patch . . . 2740
23.14.6 HTXFormatPage7xPatch3A patch . . . 2740
23.15 htxformatpage8 . . . 2741
23.15.1 Bitmaps and Images . . . 2741
23.15.2 HTXFormatPage8xPatch1 patch . . . 2742
23.15.3 HTXFormatPage8xPatch2 patch . . . 2742
23.15.4 HTXFormatPage8xPatch2A patch . . . 2743
23.16 htxformattoppage.ht . . . 2743
23.16.1 Formatting in Hyperdoc . . . 2743
23.17 htxintropage1.ht . . . 2744
23.17.1 What Hyperdoc does . . . 2744
23.18 htxintropage2.ht . . . 2745
23.18.1 How Hyperdoc does it . . . 2745
23.19 htxintropage3.ht . . . 2746
23.19.1 A simple text page . . . 2746
23.20 htxintrotoppage.ht . . . 2748
23.20.1 First Steps . . . 2748
23.21 htxlinkpage1.ht . . . 2749
23.21.1 Linking to a named page . . . 2749
23.21.2 HTXLinkPage1xPatch1 patch . . . 2751
23.21.3 HTXLinkPage1xPatch1A patch . . . 2751
23.21.4 Test Help Page . . . 2751
23.22 htxlinkpage2.ht . . . 2752
23.22.1 Standard Pages . . . 2752
23.22.2 HTXLinkPage2xPatch1 patch . . . 2754
23.22.3 HTXLinkPage2xPatch1A patch . . . 2754
23.23 htxlinkpage3.ht . . . 2754

23.23.1 Active Axiom commands . . . 2754
23.23.2 HTXLinkPage3xPatch1 patch . . . 2758
23.23.3 HTXLinkPage3xPatch1A patch . . . 2758
23.23.4 HTXLinkPage3xPatch2 patch . . . 2758
23.23.5 HTXLinkPage3xPatch2A patch . . . 2759
23.23.6 HTXLinkPage3xPatch3 patch . . . 2759
23.23.7 HTXLinkPage3xPatch3A patch . . . 2759
23.24 htxlinkpage4.ht . . . 2760
23.24.1 Linking to Lisp . . . 2760
23.24.2 HTXLinkPage4xPatch1 patch . . . 2764
23.24.3 HTXLinkPage4xPatch1A patch . . . 2764
23.24.4 HTXLinkPage4xPatch2 patch . . . 2765
23.24.5 HTXLinkPage4xPatch2A patch . . . 2765
23.24.6 HTXLinkPage4xPatch3 patch . . . 2766
23.24.7 HTXLinkPage4xPatch3A patch . . . 2766
23.24.8 HTXLinkPage4xPatch4 patch . . . 2766
23.24.9 HTXLinkPage4xPatch4A patch . . . 2766
23.24.10 HTXLinkPage4xPatch5 patch . . . 2767
23.24.11 HTXLinkPage4xPatch5A patch . . . 2767
23.25 htxlinkpage5.ht . . . 2768
23.25.1 Linking to Unix . . . 2768
23.25.2 HTXLinkPage5xPatch1 patch . . . 2769
23.25.3 HTXLinkPage5xPatch1A patch . . . 2770
23.25.4 HTXLinkPage5xPatch2 patch . . . 2770
23.25.5 HTXLinkPage5xPatch2A patch . . . 2770
23.26 htxlinkpage6.ht . . . 2771
23.26.1 How to use your pages with Hyperdoc . . . 2771
23.26.2 HTXLinkPage6xPatch1 patch . . . 2773
23.26.3 HTXLinkPage6xPatch1A patch . . . 2774
23.26.4 HTXLinkPage6xPatch2 patch . . . 2774
23.26.5 HTXLinkPage6xPatch2A patch . . . 2775
23.27 htxlinktoppage.ht . . . 2775
23.27.1 Actions in Hyperdoc . . . 2775
23.28 htxtoppage.ht . . . 2776
23.28.1 Extending Hyperdoc . . . 2776
23.29 htxtrypage.ht . . . 2777
23.29.1 Try out Hyperdoc . . . 2777

24 NAG Library Routines 2779
24.1 nagaux.ht . . . 2779
24.1.1 NAG On-line Documentation . . . 2779
24.1.2 NAG Documentation: summary . . . 2782
24.1.3 NAG Documentation: introduction . . . 2803
24.1.4 NAG Documentation: keyword in context . . . 2819
24.1.5 NAG Documentation: conversion . . . 2910
24.2 nagc.ht . . . 2913

24.2.1 Zeros of Polynomials . . . 2913
24.2.2 Roots of a complex polynomial equation . . . 2917
24.2.3 Roots of a real polynomial equation . . . 2923
24.2.4 Roots of One or More Transcendental Equations . . . 2928
24.2.5 Zero of a continuous function in a given interval . . . 2933
24.2.6 Solution of a system of nonlinear equations . . . 2937
24.2.7 Solution of a system of nonlinear equations . . . 2942
24.2.8 Checks the gradients of a set of non-linear functions . . . 2947
24.2.9 Discrete Fourier transform of real or complex data values . . . 2950
24.2.10 Discrete Fourier transform of n real data values . . . 2958
24.2.11 Discrete Fourier transform of a Hermitian sequence . . . 2962
24.2.12 Discrete Fourier transform of n complex data values . . . 2966
24.2.13 Circular convolution or correlation of two real vectors . . . 2969
24.2.14 Discrete Fourier transforms of m sequences . . . 2973
24.2.15 Discrete Fourier transforms of m Hermitian sequences . . . 2978
24.2.16 Discrete Fourier transforms of m complex sequences . . . 2983
24.2.17 Discrete Fourier transform of bivariate complex data . . . 2987
24.2.18 Summation of Series . . . 2992
24.2.19 Complex conjugate of a sequence of n data values . . . 2994
24.2.20 Complex conjugates of m Hermitian sequences . . . 2996
24.2.21 Form real and imaginary parts of m Hermitian sequences . . . 2999
24.3 nagd.ht . . . 3002
24.3.1 Quadrature . . . 3002
24.3.2 Approximation of the integral over a finite interval . . . 3015
24.3.3 Adaptive integration over a finite integral . . . 3021
24.3.4 Approximate integration with local singular points . . . 3026
24.3.5 Approximate integration over a (semi-)infinite interval . . . 3032
24.3.6 Approximate sine or cosine transform over finite interval . . . 3038
24.3.7 Adaptive integration of weighted function over an interval . . . 3045
24.3.8 Hilbert transform over finite interval . . . 3051
24.3.9 Approximate Sine or Cosine over $[a,\infty]$ . . . 3057
24.3.10 Weights and abscissae for Gaussian quadrature formula . . . 3064
24.3.11 Multidimensional integrals with finite limits . . . 3070
24.3.12 Third-order finite-difference integration . . . 3075
24.3.13 Monte Carlo integration over hyper-rectangular regions . . . 3078
24.3.14 Ordinary Differential Equations . . . 3084
24.3.15 First-order ODE over an interval with initial conditions . . . 3090
24.3.16 First-order ODE with initial conditions and user function . . . 3098
24.3.17 First-order ODE with variable-order, variable-step . . . 3106
24.3.18 Stiff First-order ODE with variable order and step . . . 3115
24.3.19 Two-point boundary-value ODE . . . 3124
24.3.20 Two-point boundary value ODE with deferred correction . . . 3131
24.3.21 Eignevalue of regular singular 2nd-order Sturm-Liouville . . . 3139
24.3.22 Two-point boundary-value ODE equation systems . . . 3161
24.3.23 Partial differential equations . . . 3174
24.3.24 Discrete elliptic PDE on rectangular region . . . 3181

24.3.25 Discrete 2nd-order elliptic PDE on rectangular regions 3189
24.3.26 Helmholtz equation in 3 dimensions 3201
24.4 nage.ht 3210
24.4.1 Interpolation 3210
24.4.2 Cubic spline interpolant 3216
24.4.3 Monoticity-preserving piecewise cubic Hermite interpolant 3221
24.4.4 Piecewise cubic Hermite interpolant 3224
24.4.5 Piecewise cubic Hermite interpolant and 1st deriv 3227
24.4.6 Definite integral of piecewise cubic Hermite interpolant 3230
24.4.7 Bicubic spline interpolated surface 3233
24.4.8 Two-D surface interpolating a set of scattered data points 3239
24.4.9 Evaluate 2D interpolant function from E01SAF 3243
24.4.10 Generate 2D surface interpolating a scattered data points 3246
24.4.11 Evaluate 2D interpolating function from E01SEF 3252
24.4.12 Curve and Surface Fitting 3255
24.4.13 Least-squares polynomial approximations 3279
24.4.14 Evaluate polynomial from Chebyshev-series representation 3285
24.4.15 Constrained weighted least-squares polynomial 3289
24.4.16 Coefficients of polynomial derivative 3297
24.4.17 Find coefficients of indefinite integral of polynomial 3302
24.4.18 Evaluate polynomial in Chebyshev-series representation 3308
24.4.19 Weighted least-squares aprrox to data points 3312
24.4.20 Evaluates a cubic spline from its B-spline representation 3319
24.4.21 Evaluate cubic spline and 3 derivatives from B-spline 3323
24.4.22 Definite integral of cubic spline from B-spline 3329
24.4.23 Cubic spline approximation to an arbitrary set points 3333
24.4.24 Minimal, weighted least-squares bicubic spline fit 3342
24.4.25 Bicubic spline approximation to a set of data values 3351
24.4.26 Bicubic spline approximation to a set of scattered data 3362
24.4.27 Calculates values of a bicubic spline from B-spline 3373
24.4.28 Calculates values of a bicubic spline from B-spline 3377
24.4.29 Calculates l_1 solution to over-determined system equations 3382
24.4.30 Sorts two-dimensional data into rectangular panels 3388
24.4.31 Minimizing or Maximizing a Function 3392
24.4.32 Minimizes a nonlinear function of several variable 3416
24.4.33 Supply optional parameters to E04DGF from file 3430
24.4.34 Supply individual optional params to E04DGF 3434
24.4.35 Finding an unconstrained minimum of a sum of squares 3437
24.4.36 Finding an unconstrained minimum of a sum of squares 3443
24.4.37 Finding a minimum of a function 3449
24.4.38 Solving linear programming problems 3456
24.4.39 Solving linear or quadratic problems 3464
24.4.40 Minimize an arbitrary smooth constrainted function 3483
24.4.41 Supply optional parameters to E04UCF from file 3531
24.4.42 Supply individual optional params to E04UCF 3534
24.4.43 Estimates of elements of the variance-covariance matrix 3537

24.5 nagf.ht 3544
24.5.1 Linear Algebra 3544
24.5.2 Matrix Factorization 3548
24.5.3 Factorizes a real sparse matrix 3551
24.5.4 Factorizes a real sparse matrix 3560
24.5.5 Incomplete Cholesky factorization 3566
24.5.6 Cholesky factor of a symmetric positive-definite matrix 3574
24.5.7 QR factorization of the real m by n matrix A 3578
24.5.8 $B := QB$ or $B := Q^T B$ 3583
24.5.9 First ncolq columns of the real m by m orthogonal matrix 3589
24.5.10 QR factorization of the complex m by n matrix A 3593
24.5.11 $B := QB$ or $B := Q^H B$ 3598
24.5.12 First ncolq columns of the complex m by m unitary matrix 3604
24.5.13 Eigenvalues and Eigenvectors 3609
24.5.14 Calculates all the eigenvalues of a real symmetric matrix 3615
24.5.15 Eigenvalues and eigenvectors of a real symmetric matrix 3618
24.5.16 Calculates all the eigenvalues of $Ax = \lambda Bx$ 3621
24.5.17 Eigenvalues and eigenvectors of $Ax = \lambda Bx$ 3624
24.5.18 Calculates all the eigenvalues of a real unsymmetric matrix 3628
24.5.19 Eigenvalues and eigenvectors of a real unsymmetric matrix 3631
24.5.20 Calculates all the eigenvalues of a complex matrix 3634
24.5.21 Eigenvalues and eigenvectors of a complex matrix 3637
24.5.22 Eigenvalues of a complex Hermitian matrix 3640
24.5.23 Eigenvalues/eigenvectors complex Hermitian matrix 3643
24.5.24 Eigenvalues and eigenvectors of a real symmetric matrix 3647
24.5.25 Eigenvalues of generalized eigenproblem $Ax = \lambda Bx$ 3651
24.5.26 Eigenvalues and eigenvectors of real sparse symmetric problem 3656
24.5.27 Singular value decomposition of a general real matrix 3669
24.5.28 Singular value decomposition of a general complex matrix 3676
24.5.29 Simultaneous Linear Equations 3684
24.5.30 Approximate solution of a set of complex linear equations 3689
24.5.31 Approximate solution of a set of real linear equations 3693
24.5.32 Real symmetric positive-definite linear equations 3696
24.5.33 Set of real linear equations with a single right-hand side 3700
24.5.34 Solution of a set of real sparse linear equations 3704
24.5.35 Real symmetric positive-definite tridiagonal linear equations 3708
24.5.36 Solution of a linear least-squares problem, $Ax = b$ 3713
24.5.37 Sparse symmetric positive-definite system linear equations 3719
24.5.38 Solves a system of real sparse symmetric linear equations 3725
24.5.39 Solution of a system of real linear equations 3736
24.5.40 Solves sparse unsymmetric equations 3741
24.5.41 Linear Algebra Support Routines 3754
24.5.42 Linear Equations (LAPACK) 3785
24.5.43 Computes the LU factorization of a real m by n matrix 3787
24.5.44 Solves a real system of linear equations 3790
24.5.45 Factorization of a real symmetric positive-definite matrix 3794

24.5.46 Real symmetric positive-definite system of linear equations 3798
24.5.47 Sort vector of double precision numbers 3805
24.5.48 Ranks a vector of double precision numbers 3807
24.5.49 Ranks the rows of a matrix of double precision numbers 3810
24.5.50 Ranks the columns of a matrix of double precision numbers 3812
24.5.51 Rearranges a vector of double precision numbers 3815
24.5.52 Inverts a permutation 3818
24.6 nags.ht 3821
24.6.1 Approximations of Special Functions 3821
24.6.2 Exponential function e^z , for complex z 3833
24.6.3 Returns the value of the exponential integral $E(x)$ 3837
24.6.4 Returns the value of the cosine integral 3840
24.6.5 Returns the value of the sine integral 3843
24.6.6 Returns the value of the Gamma function 3846
24.6.7 Returns a value for the logarithm of the Gamma function 3850
24.6.8 Incomplete gamma functions P(a,x) and Q(a,x) 3854
24.6.9 Returns the value of the complementary error function 3857
24.6.10 Returns the value of the error function erfx 3861
24.6.11 Returns the value of the Bessel Function $Y_0(x)$ 3864
24.6.12 Returns the value of the Bessel Function $Y_1(x)$ 3868
24.6.13 Returns the value of the Bessel Function $J_0(x)$ 3872
24.6.14 Returns the value of the Bessel Function $J_1(x)$ 3876
24.6.15 Returns a value for the Airy function, $Ai(x)$ 3880
24.6.16 Returns a value of the Airy function, $Bi(x)$ 3885
24.6.17 Value of the derivative of the Airy function $Ai(x)$ 3889
24.6.18 Value for the derivative of the Airy function $Bi(x)$ 3894
24.6.19 Values for the Bessel functions $Y_{\nu+n}(z)$ 3898
24.6.20 Values for the Bessel functions $J_{\nu+n}(z)$ 3903
24.6.21 Value of the Airy function $Ai(z)$ or derivative $Ai'(z)$ 3908
24.6.22 Value of the Airy function $Bi(z)$ or derivative $Bi'(z)$ 3912
24.6.23 Returns a sequence of values for the Hankel functions 3916
24.6.24 Returns the value of the modified Bessel Function $K_0(x)$ 3922
24.6.25 Returns the value of the modified Bessel Function $K_1(x)$ 3926
24.6.26 Returns the value of the modified Bessel Function $I_0(x)$ 3930
24.6.27 Returns a value for the modified Bessel Function $I_1(x)$ 3933
24.6.28 Sequence of values for the modified Bessel $K_{\nu_n}(z)$ 3937
24.6.29 Sequence of values for the modified Bessel $I_{\nu+n}$ 3942
24.6.30 Returns a value for the Kelvin function ber x 3947
24.6.31 Returns a value for the Kelvin function bei x 3950
24.6.32 Returns a value for the Kelvin function ker x 3954
24.6.33 Returns a value for the Kelvin function keix 3958
24.6.34 Returns a value for the Fresnel Integral $S(x)$ 3962
24.6.35 Returns a value for the Fresnel Integral $C(x)$ 3966
24.6.36 Returns a value of an elementary integral 3971
24.6.37 Value of the symmetrised elliptic integral of first kind 3975
24.6.38 Value of the symmetrised elliptic integral of second kind 3979

24.6.39 Value of the symmetrised elliptic integral of third kind 3984
24.7 nagx.ht 3989
24.7.1 Mathematical Constants 3989
24.7.2 Machine Constants 3990
24.7.3 Input/Output Utilities 3996
24.7.4 Value of the current error message unit number 3998
24.7.5 Value of the current advisory message unit number 4000
24.7.6 Print a real matrix stored in a two-dimensional array 4002
24.7.7 Print a complex matrix stored in a 2D array 4006
24.7.8 Date and Time Utilities 4009
24.7.9 Returns the current date and time 4011
24.7.10 From seven-integer format time and date to character string 4012
24.7.11 Compares two date/time character strings 4015
24.7.12 Amount of processor time used 4017

25 NAG ASP Example Code 4021
25.1 aspex.ht 4021
25.1.1 Asp1 Example Code 4021
25.1.2 Asp10 Example Code 4021
25.1.3 Asp12 Example Code 4022
25.1.4 Asp19 Example Code 4022
25.1.5 Asp20 Example Code 4024
25.1.6 Asp24 Example Code 4025
25.1.7 Asp27 Example Code 4025
25.1.8 Asp28 Example Code 4026
25.1.9 Asp29 Example Code 4028
25.1.10 Asp30 Example Code 4029
25.1.11 Asp31 Example Code 4030
25.1.12 Asp33 Example Code 4030
25.1.13 Asp34 Example Code 4030
25.1.14 Asp35 Example Code 4031
25.1.15 Asp4 Example Code 4032
25.1.16 Asp41 Example Code 4032
25.1.17 Asp42 Example Code 4033
25.1.18 Asp49 Example Code 4034
25.1.19 Asp50 Example Code 4034
25.1.20 Asp55 Example Code 4035
25.1.21 Asp6 Example Code 4036
25.1.22 Asp7 Example Code 4037
25.1.23 Asp73 Example Code 4037
25.1.24 Asp74 Example Code 4037
25.1.25 Asp77 Example Code 4038
25.1.26 Asp78 Example Code 4038
25.1.27 Asp8 Example Code 4039
25.1.28 Asp80 Example Code 4040
25.1.29 Asp9 Example Code 4040

26 NAG ANNA Expert System **4041**
26.1 annaex.ht 4041
26.1.1 Axiom/NAG Expert System 4041
26.1.2 Integration 4042
26.1.3 Ordinary Differential Equations 4042
26.1.4 Optimization 4043
26.1.5 Partial Differential Equations 4044
26.1.6 Examples Using the Axiom/NAG Expert System 4045
26.1.7 Examples Using the Axiom/NAG Expert System 4046
26.1.8 Examples Using the Axiom/NAG Expert System 4046
26.1.9 Examples Using the Axiom/NAG Expert System 4048
26.1.10 About the Axiom/NAG Expert System 4049
26.1.11 Introduction to the Axiom/NAG Expert System 4049
26.1.12 Example using the Axiom/NAG Expert System 4051
26.1.13 Example using the Axiom/NAG Expert System 4055
26.1.14 Example using the Axiom/NAG Expert System 4056
26.1.15 Decision Agents 4057
26.1.16 Inference Mechanisms 4058
26.1.17 Method Domains 4059
26.1.18 Measure Functions 4060
26.1.19 Computational Agents 4061

27 ANNA Algebra Code **4063**

28 Page hierarchy layout **4065**

29 Makefile **4097**

Bibliography **4099**

Index **4101**

Volume 8: Axiom Graphics

1 Overview **1**
1.1 Environment Settings . . . 1
1.1.1 X11 .Xdefaults . . . 1
1.1.2 Shell Variables . . . 2
1.2 Pre-release change history . . . 2

2 Graphics File Formats **7**
2.1 The viewFile data file format . . . 7
2.1.1 The viewType . . . 7
2.1.2 The title . . . 7
2.1.3 The window boundaries . . . 7
2.1.4 The graph specifications . . . 8
2.2 The graph file format . . . 10
2.2.1 The bounding values . . . 10
2.3 The parabola . . . 11
2.4 3D graph information . . . 14

3 include **17**
3.1 actions.h . . . 17
3.2 colors.h . . . 19
3.3 component.h . . . 21
3.4 g.h . . . 22
3.5 nox10.h . . . 23
3.6 override.h . . . 25
3.7 rgb.h . . . 25
3.8 spadcolors.h . . . 25
3.9 tube.h . . . 26
3.10 view2d.h . . . 28
3.11 view3d.h . . . 30
3.12 viewcommand.h . . . 32
3.13 view.h . . . 32
3.14 write.h . . . 34
3.15 xdefs.h . . . 34

4 viewman **73**
4.1 viewman Call Graph . . . 73
4.2 Constants and Headers . . . 75
4.2.1 defines . . . 75
4.2.2 System includes . . . 76
4.2.3 Local includes . . . 76
4.2.4 extern references . . . 76
4.2.5 forward references . . . 77
4.2.6 global variables . . . 77

4.3 Code . . . 78
4.3.1 endChild . . . 78
4.3.2 rmViewMgr . . . 78
4.3.3 closeChildViewport . . . 80
4.3.4 goodbye . . . 80
4.3.5 funView2D . . . 80
4.3.6 forkView2D . . . 82
4.3.7 sendGraphToView2D . . . 84
4.3.8 funView3D . . . 86
4.3.9 forkView3D . . . 88
4.3.10 makeView2DFromSpadData . . . 91
4.3.11 makeView3DFromSpadData . . . 92
4.3.12 makeGraphFromSpadData . . . 94
4.3.13 discardGraph . . . 95
4.3.14 readViewport . . . 95
4.3.15 superSelect . . . 95
4.3.16 brokenPipe . . . 96
4.3.17 main . . . 96

5 viewalone **101**
5.1 viewalone Call Graph . . . 101
5.2 Constants and Headers . . . 102
5.2.1 System includes . . . 102
5.2.2 Local includes . . . 103
5.2.3 defines . . . 103
5.2.4 extern references . . . 103
5.2.5 global variables . . . 104
5.3 Code . . . 104
5.3.1 sendGraphToView2D . . . 104
5.3.2 makeView2DFromFileData . . . 106
5.3.3 makeView3DFromFileData . . . 109
5.3.4 spoonView2D . . . 111
5.3.5 spoonView3D . . . 112
5.3.6 main . . . 114

6 view2d **117**
6.1 view2d Call Graph . . . 117
6.2 Constants and Headers . . . 125
6.2.1 System includes . . . 125
6.2.2 local includes . . . 126
6.2.3 static variables . . . 126
6.2.4 structs . . . 126
6.2.5 defines . . . 128
6.2.6 extern references . . . 133
6.2.7 forward references . . . 133
6.2.8 global variables . . . 135

6.3 Code . . . 137
6.3.1 initButtons . . . 137
6.3.2 writeControlTitle . . . 148
6.3.3 makeMessageFromData . . . 149
6.3.4 writeControlMessage . . . 149
6.3.5 drawControlPanel . . . 150
6.3.6 getControlXY . . . 153
6.3.7 makeControlPanel . . . 155
6.3.8 putControlPanelSomewhere . . . 156
6.3.9 clearControlMessage . . . 157
6.3.10 getGraphFromViewman . . . 157
6.3.11 freeGraph . . . 159
6.3.12 mergeDatabases . . . 159
6.3.13 getPotValue . . . 160
6.3.14 doPick . . . 160
6.3.15 doDrop . . . 161
6.3.16 clickedOnGraphSelect . . . 161
6.3.17 drawControlPushButton . . . 163
6.3.18 buttonAction . . . 163
6.3.19 processEvents . . . 168
6.3.20 clickedOnGraph . . . 174
6.3.21 readViewman . . . 175
6.3.22 spadAction . . . 175
6.3.23 absolute . . . 179
6.3.24 goodbye . . . 179
6.3.25 writeTitle . . . 180
6.3.26 drawTheViewport . . . 180
6.3.27 makeViewport . . . 188
6.3.28 makeView2D . . . 190
6.3.29 writeViewport . . . 190
6.3.30 main . . . 193

7 view3d 199
7.1 view3d Call Graph . . . 199
7.2 Constants and Headers . . . 211
7.2.1 System includes . . . 211
7.2.2 Local includes . . . 211
7.2.3 defines . . . 212
7.2.4 static variables . . . 224
7.2.5 structs . . . 226
7.2.6 extern references . . . 228
7.2.7 forward references . . . 230
7.2.8 global variables . . . 233
7.3 Code . . . 238
7.3.1 initButtons . . . 238
7.3.2 closeViewport . . . 244

7.3.3 scaleComponents . . . 245
7.3.4 makeTriangle . . . 246
7.3.5 triangulate . . . 247
7.3.6 readComponentsFromViewman . . . 249
7.3.7 calcNormData . . . 250
7.3.8 make3DComponents . . . 251
7.3.9 draw3DComponents . . . 252
7.3.10 drawColorMap . . . 259
7.3.11 writeControlTitle . . . 260
7.3.12 clearControlMessage . . . 260
7.3.13 writeControlMessage . . . 261
7.3.14 drawControlPanel . . . 261
7.3.15 getControlXY . . . 271
7.3.16 makeControlPanel . . . 272
7.3.17 putControlPanelSomewhere . . . 274
7.3.18 phong . . . 275
7.3.19 hueValue . . . 276
7.3.20 getHue . . . 276
7.3.21 Value . . . 276
7.3.22 hlsTOrgb . . . 277
7.3.23 initLightButtons . . . 277
7.3.24 makeLightingPanel . . . 279
7.3.25 drawLightingAxes . . . 281
7.3.26 drawLightTransArrow . . . 282
7.3.27 drawLightingPanel . . . 284
7.3.28 theHandler . . . 287
7.3.29 mergeDatabases . . . 288
7.3.30 getMeshNormal . . . 289
7.3.31 normalizeVector . . . 289
7.3.32 dotProduct . . . 290
7.3.33 merge . . . 290
7.3.34 msort . . . 291
7.3.35 getPotValue . . . 292
7.3.36 getLinearPotValue . . . 292
7.3.37 buttonAction . . . 292
7.3.38 processEvents . . . 306
7.3.39 project . . . 319
7.3.40 projectAPoint . . . 320
7.3.41 projectAllPoints . . . 320
7.3.42 projectAllPolys . . . 321
7.3.43 projectAPoly . . . 322
7.3.44 projectStuff . . . 323
7.3.45 makeQuitPanel . . . 324
7.3.46 drawQuitPanel . . . 325
7.3.47 initQuitButtons . . . 326
7.3.48 makeSavePanel . . . 327

7.3.49 drawSavePanel . . . 328
7.3.50 initSaveButtons . . . 328
7.3.51 getCBufferAxes . . . 329
7.3.52 putCBufferAxes . . . 330
7.3.53 getCBufferIndx . . . 330
7.3.54 putCBufferIndx . . . 330
7.3.55 putZBuffer . . . 330
7.3.56 getZBuffer . . . 331
7.3.57 putImageX . . . 331
7.3.58 drawPhongSpan . . . 331
7.3.59 scanPhong . . . 332
7.3.60 boxTObuffer . . . 335
7.3.61 clipboxTObuffer . . . 336
7.3.62 axesTObuffer . . . 337
7.3.63 scanLines . . . 338
7.3.64 freePolyList . . . 341
7.3.65 showAxesLabels . . . 342
7.3.66 makeTriangle . . . 343
7.3.67 drawPhong . . . 344
7.3.68 readViewman . . . 347
7.3.69 scalePoint . . . 347
7.3.70 spadAction . . . 347
7.3.71 traverse . . . 353
7.3.72 absolute . . . 353
7.3.73 getRandom . . . 353
7.3.74 normDist . . . 353
7.3.75 goodbye . . . 354
7.3.76 drawLineComponent . . . 354
7.3.77 drawOpaquePolygon . . . 355
7.3.78 copyPolygons . . . 356
7.3.79 minMaxPolygons . . . 358
7.3.80 polyCompare . . . 359
7.3.81 makeTriangle . . . 359
7.3.82 makeTriangle . . . 359
7.3.83 freePointResevoir . . . 362
7.3.84 freeListOfPolygons . . . 362
7.3.85 drawPolygons . . . 362
7.3.86 lessThan . . . 365
7.3.87 greaterThan . . . 365
7.3.88 isNaN . . . 366
7.3.89 isNaNPoint . . . 366
7.3.90 equal . . . 366
7.3.91 matrixMultiply4x4 . . . 366
7.3.92 vectorMatrix4 . . . 367
7.3.93 ROTATE . . . 367
7.3.94 ROTATE1 . . . 368

7.3.95 SCALE . . . 368
7.3.96 TRANSLATE . . . 369
7.3.97 writeTitle . . . 369
7.3.98 drawPreViewport . . . 369
7.3.99 drawTheViewport . . . 375
7.3.100 makeViewport . . . 376
7.3.101 postMakeViewport . . . 380
7.3.102 keepDrawingViewport . . . 382
7.3.103 initVolumeButtons . . . 382
7.3.104 makeVolumePanel . . . 385
7.3.105 drawClipXBut . . . 386
7.3.106 drawClipYBut . . . 387
7.3.107 drawClipZBut . . . 388
7.3.108 drawClipVolume . . . 389
7.3.109 drawHitherControl . . . 390
7.3.110 drawEyeControl . . . 391
7.3.111 drawFrustrum . . . 392
7.3.112 drawVolumePanel . . . 393
7.3.113 writeViewport . . . 395
7.3.114 main . . . 398

8 gdraws **405**
8.0.115 Gdraw . . . 405
8.0.116 To use G Functions . . . 406
8.1 gfun.c . . . 407
8.1.1 filecopy . . . 408
8.1.2 PSCreateFile . . . 408
8.1.3 GdrawsDrawFrame . . . 409
8.1.4 GdrawsSetDimension . . . 410
8.1.5 GDrawImageString . . . 410
8.1.6 GDrawArc . . . 411
8.1.7 GDrawLine . . . 412
8.1.8 GDrawLines . . . 413
8.1.9 GDrawPoint . . . 413
8.1.10 GDrawRectangle . . . 414
8.1.11 GDraw3DButtonIn . . . 415
8.1.12 GDraw3DButtonIn . . . 415
8.1.13 GDrawPushButton . . . 416
8.1.14 GDrawString . . . 416
8.1.15 GFillArc . . . 417
8.1.16 PSGlobalInit . . . 418
8.1.17 PSInit . . . 420
8.1.18 PSCreateContext . . . 420
8.1.19 PSfindGC . . . 421
8.1.20 GSetForeground . . . 422
8.1.21 GSetBackground . . . 422

8.1.22 GSetLineAttributes . . . 423
8.1.23 PSClose . . . 425
8.1.24 centerX . . . 425
8.1.25 centerY . . . 425
8.1.26 PSColorPolygon . . . 426
8.1.27 PSColorwOutline . . . 426
8.1.28 PSDrawColor . . . 427
8.1.29 PSFillPolygon . . . 428
8.1.30 PSFillwOutline . . . 428
8.1.31 TrivEqual . . . 429
8.1.32 TrivHashCode . . . 429
8.1.33 XCreateAssocTable . . . 429
8.1.34 XMakeAssoc . . . 430
8.1.35 XLookUpAssoc . . . 430
8.1.36 XDeleteAssoc . . . 430
8.2 The postscript command definitions . . . 430
8.2.1 colorpoly . . . 430
8.2.2 colorwol . . . 431
8.2.3 drawarc . . . 432
8.2.4 drawcolor . . . 432
8.2.5 drawIstr . . . 433
8.2.6 drawline . . . 434
8.2.7 drawlines . . . 434
8.2.8 drawpoint . . . 435
8.2.9 draw . . . 435
8.2.10 drawrect . . . 436
8.2.11 drawstr . . . 436
8.2.12 drwfilled . . . 437
8.2.13 end . . . 437
8.2.14 fillarc . . . 438
8.2.15 fillpoly . . . 439
8.2.16 fillwol . . . 439
8.2.17 header . . . 440
8.2.18 setup . . . 443

9 The APIs 445
9.1 Graphics API . . . 445
9.1.1 XDrawString . . . 445
9.1.2 XDrawPoint . . . 445
9.1.3 XDrawLine . . . 446
9.1.4 XDrawImageString . . . 446
9.1.5 XFillArc . . . 447
9.1.6 XDrawArc . . . 448
9.1.7 XSetForeground . . . 449
9.1.8 XSetBackground . . . 449
9.1.9 XSetLineAttributes . . . 449

9.1.10 DefaultScreen . . . 450
9.1.11 RootWindow . . . 450
9.1.12 XCreateAssocTable . . . 450
9.1.13 XOpenDisplay . . . 450
9.2 X11 API calls . . . 451

10 libspad **457**
10.1 bsdsignal.c . . . 457
10.2 cfuns-c.c . . . 462
10.3 cursor.c . . . 465
10.4 edin.c . . . 467
10.5 emupty.c . . . 484
10.6 fnct-key.c . . . 488
10.7 halloc.c . . . 494
10.8 hash.c . . . 495
10.9 openpty.c . . . 499
10.10 pixmap.c . . . 503
10.11 prt.c . . . 509
10.12 sockio-c.c . . . 516
10.13 spadcolors.c . . . 535
10.14 util.c . . . 546
10.15 wct.c . . . 548
10.16 xdither.c . . . 562
10.17 xshade.c . . . 565
10.18 xspadfill.c . . . 569
10.19 edible.c . . . 574
10.19.1 edible Call Graph . . . 574

11 Makefile **589**

Bibliography **593**

Index **595**

Volume 8.1: Axiom Gallery

1 General examples **1**
1.1 Two dimensional functions . . . 1
1.1.1 A Simple Sine Function . . . 2
1.1.2 A Simple Sine Function, Non-adaptive plot . . . 3
1.1.3 A Simple Sine Function, Drawn to Scale . . . 4
1.1.4 A Simple Sine Function, Polar Plot . . . 5
1.1.5 A Simple Tangent Function, Clipping On . . . 6
1.1.6 A Simple Tangent Function, Clipping On . . . 7
1.1.7 Tangent and Sine . . . 8
1.1.8 A 2D Sine Function in BiPolar Coordinates . . . 9
1.1.9 A 2D Sine Function in Elliptic Coordinates . . . 10
1.1.10 A 2D Sine Wave in Polar Coordinates . . . 11
1.2 Two dimensional curves . . . 11
1.2.1 A Line in Parabolic Coordinates . . . 12
1.2.2 Lissajous Curve . . . 13
1.2.3 A Parametric Curve . . . 14
1.2.4 A Parametric Curve in Polar Coordinates . . . 15
1.3 Three dimensional functions . . . 15
1.3.1 A 3D Constant Function in Elliptic Coordinates . . . 16
1.3.2 A 3D Constant Function in Oblate Spheroidal . . . 17
1.3.3 A 3D Constant in Polar Coordinates . . . 18
1.3.4 A 3D Constant in Prolate Spheroidal Coordinates . . . 19
1.3.5 A 3D Constant in Spherical Coordinates . . . 20
1.3.6 A 2-Equation Space Function . . . 21
1.4 Three dimensional curves . . . 21
1.4.1 A Parametric Space Curve . . . 22
1.4.2 A Tube around a Parametric Space Curve . . . 23
1.4.3 A 2-Equation Cylindrical Curve . . . 24
1.5 Three dimensional surfaces . . . 24
1.5.1 A Icosahedron . . . 25
1.5.2 A 3D figure 8 immersion (Klein bagel) . . . 27
1.5.3 A 2-Equation bipolarCylindrical Surface . . . 28
1.5.4 A 3-Equation Parametric Space Surface . . . 29
1.5.5 A 3D Vector of Points in Elliptic Cylindrical . . . 30
1.5.6 A 3D Constant Function in BiPolar Coordinates . . . 31
1.5.7 A Swept in Parabolic Coordinates . . . 32
1.5.8 A Swept Cone in Parabolic Cylindrical Coordinates . . . 33
1.5.9 A Truncated Cone in Toroidal Coordinates . . . 34
1.5.10 A Swept Surface in Paraboloidal Coordinates . . . 35

2 Jenks Book images **37**
2.0.11 The Complex Gamma Function . . . 38
2.0.12 The Complex Arctangent Function . . . 39

3 Hyperdoc examples **41**
3.1 Two dimensional examples . . . 41
3.1.1 A function of one variable . . . 42
3.1.2 A Parametric function . . . 43
3.1.3 A Polynomial in 2 variables . . . 44
3.2 Three dimensional examples . . . 44
3.2.1 A function of two variables . . . 45
3.2.2 A parametrically defined curve . . . 46
3.2.3 A parametrically defined surface . . . 47

4 CRC Standard Curves and Surfaces **49**
4.1 Standard Curves and Surfaces . . . 49
4.2 CRC graphs . . . 50
4.2.1 Functions with $x^{n/m}$ . . . 50
4.2.2 Functions with x^n and $(a+bx)^m$ . . . 61
4.2.3 Functions with a^2+x^2 and x^m . . . 116
4.2.4 Functions with a^2-x^2 and x^m . . . 130
4.2.5 Functions with a^3+x^3 and x^m . . . 144
4.2.6 Functions with a^3-x^3 and x^m . . . 155
4.2.7 Functions with a^4+x^4 and x^m . . . 166
4.2.8 Functions with a^4-x^4 and x^m . . . 177
4.2.9 Functions with $(a+bx)^{1/2}$ and x^m . . . 188

5 Pasta by Design **207**
5.1 Acini Di Pepe . . . 208
5.2 Agnolotti . . . 209
5.3 Anellini . . . 210
5.4 Bucatini . . . 211
5.5 Buccoli . . . 212
5.6 Calamaretti . . . 213
5.7 Cannelloni . . . 214
5.8 Cannolicchi Rigati . . . 215
5.9 Capellini . . . 216
5.10 Cappelletti . . . 217
5.11 Casarecce . . . 218
5.12 Castellane . . . 219
5.13 Cavatappi . . . 220
5.14 Cavatelli . . . 221
5.15 Chifferi Rigati . . . 222
5.16 Colonne Pompeii . . . 223
5.17 Conchiglie Rigate . . . 225
5.18 Conchigliette Lisce . . . 226
5.19 Conchiglioni Rigate . . . 227
5.20 Corallini Lisci . . . 228
5.21 Creste Di Galli . . . 229
5.22 Couretti . . . 230

5.23 Ditali Rigati . . . 231
5.24 Fagottini . . . 232
5.25 Farfalle . . . 233
5.26 Farfalline . . . 235
5.27 Farfalloni . . . 236
5.28 Festonati . . . 237
5.29 Fettuccine . . . 238
5.30 Fiocchi Rigati . . . 239
5.31 Fisarmoniche . . . 240
5.32 Funghini . . . 241
5.33 Fusilli . . . 242
5.34 Fusilli al Ferretto . . . 243
5.35 Fusilli Capri . . . 244
5.36 Fusilli Lunghi Bucati . . . 245
5.37 Galletti . . . 247
5.38 Garganelli . . . 248
5.39 Gemelli . . . 249
5.40 Gigli . . . 250
5.41 Giglio Ondulato . . . 251
5.42 Gnocchetti Sardi . . . 252
5.43 Gnocchi . . . 253
5.44 Gramigna . . . 254
5.45 Lancette . . . 255
5.46 Lasagna Larga Doppia Riccia . . . 256
5.47 Linguine . . . 257
5.48 Lumaconi Rigati . . . 258
5.49 Maccheroni . . . 259
5.50 Maccheroni Alla Chitarra . . . 260
5.51 Mafaldine . . . 261
5.52 Manicotti . . . 262
5.53 Orecchiette . . . 263
5.54 Paccheri . . . 264
5.55 Pappardelle . . . 265
5.56 Penne Rigate . . . 266
5.57 Pennoni Lisci . . . 267
5.58 Pennoni Rigati . . . 268
5.59 Puntalette . . . 269
5.60 Quadrefiore . . . 270
5.61 Quadretti . . . 271
5.62 Racchette . . . 272
5.63 Radiatori . . . 273
5.64 Ravioli Quadrati . . . 274
5.65 Ravioli Tondi . . . 275
5.66 Riccioli . . . 276
5.67 Riccioli al Cinque Sapori . . . 277
5.68 Rigatoni . . . 278

5.69 Rombi 279
5.70 Rotelle 280
5.71 Saccottini 281
5.72 Sagnarelli 282
5.73 Sagne Incannulate 283
5.74 Scialatielli 284
5.75 Spaccatelle 285
5.76 Spaghetti 286
5.77 Spiralli 287
5.78 Stellette 288
5.79 Stortini 289
5.80 Strozzapreti 290
5.81 Tagliatelle 291
5.82 Taglierini 292
5.83 Tagliolini 293
5.84 Torchietti 294
5.85 Tortellini 295
5.86 Tortiglioni 296
5.87 Trenne 297
5.88 Tripoline 298
5.89 Trofie 299
5.90 Trottole 300
5.91 Tubetti Rigati 301
5.92 Ziti 302

Bibliography **303**

Index **305**

Volume 9: Axiom Compiler

1 The Axiom Compiler **1**
1.1 Makefile . . . 1

2 Overview **3**
2.1 Syntax by Jacob Smith . . . 4
2.1.1 Language features . . . 13
2.1.2 Sematics . . . 13
2.2 The Input . . . 15
2.3 The Output, the EQ.nrlib directory . . . 19
2.4 The code.lsp and EQ.lsp files . . . 20
2.5 The code.o file . . . 33
2.6 The info file . . . 33
2.7 The EQ.fn file . . . 36
2.8 The index.kaf file . . . 40
2.8.1 The index offset byte . . . 41
2.8.2 The "loadTimeStuff" . . . 42
2.8.3 The "compilerInfo" . . . 44
2.8.4 The "constructorForm" . . . 50
2.8.5 The "constructorKind" . . . 50
2.8.6 The "constructorModemap" . . . 50
2.8.7 The "constructorCategory" . . . 52
2.8.8 The "sourceFile" . . . 53
2.8.9 The "modemaps" . . . 53
2.8.10 The "operationAlist" . . . 55
2.8.11 The "superDomain" . . . 56
2.8.12 The "signaturesAndLocals" . . . 56
2.8.13 The "attributes" . . . 57
2.8.14 The "predicates" . . . 57
2.8.15 The "abbreviation" . . . 58
2.8.16 The "parents" . . . 58
2.8.17 The "ancestors" . . . 58
2.8.18 The "documentation" . . . 59
2.8.19 The "slotInfo" . . . 60
2.8.20 The "index" . . . 62

3 Compiler top level **63**
3.1 Spad Program Representation . . . 63
3.2 Global Data Structures . . . 64
3.3 Pratt Parsing . . . 64
3.4)compile . . . 65
3.4.1 Spad compiler . . . 66
3.5 Operator Precedence Table Initialization . . . 67
3.5.1 LED and NUD Tables . . . 68

3.6 Gliph Table . . . 70
3.6.1 Rename Token Table . . . 71
3.6.2 Generic function table . . . 71
3.7 Giant steps, Baby steps . . . 71

4 The Parser **73**
4.1 EQ.spad . . . 73
4.2 boot transformations . . . 77
4.2.1 defun string2BootTree . . . 77
4.2.2 defun new2OldLisp . . . 78
4.2.3 defun new2OldTran . . . 78
4.2.4 defun newIf2Cond . . . 79
4.2.5 defun newDef2Def . . . 79
4.2.6 defun new2OldDefForm . . . 79
4.2.7 defun newConstruct . . . 80
4.3 preparse . . . 80
4.3.1 defvar $index . . . 80
4.3.2 defvar $linelist . . . 80
4.3.3 defvar $echolinestack . . . 81
4.3.4 defvar $preparse-last-line . . . 81
4.4 Parsing routines . . . 81
4.4.1 defun initialize-preparse . . . 81
4.4.2 defun preparse . . . 85
4.4.3 defun Build the lines from the input for piles . . . 85
4.4.4 defun skip-ifblock . . . 90
4.4.5 defun preparseReadLine1 . . . 91
4.4.6 defun expand-tabs . . . 92
4.5 I/O Handling . . . 93
4.5.1 defun preparse-echo . . . 93
4.5.2 Parsing stack . . . 93
4.5.3 defstruct stack . . . 93
4.5.4 defun stack-load . . . 93
4.5.5 defun stack-clear . . . 94
4.5.6 defmacro stack-/-empty . . . 94
4.5.7 defun stack-push . . . 94
4.5.8 defun stack-pop . . . 94
4.5.9 Parsing token . . . 95
4.5.10 defstruct token . . . 95
4.5.11 defvar prior-token . . . 95
4.5.12 defvar nonblank . . . 95
4.5.13 defvar current-token . . . 95
4.5.14 defvar next-token . . . 96
4.5.15 defvar valid-tokens . . . 96
4.5.16 defun token-install . . . 96
4.5.17 defun token-print . . . 96
4.5.18 Parsing reduction . . . 97

4.5.19 defstruct reduction 97

5 Parse Transformers **99**
5.1 Direct called parse routines 99
5.1.1 defun parseTransform 99
5.1.2 defun parseTran 99
5.1.3 defun parseAtom 100
5.1.4 defun parseTranList 101
5.1.5 defplist parseConstruct 101
5.1.6 defun parseConstruct 101
5.2 Indirect called parse routines 101
5.2.1 defplist parseAnd 102
5.2.2 defun parseAnd 103
5.2.3 defplist parseAtSign 103
5.2.4 defun parseAtSign 103
5.2.5 defun parseType 104
5.2.6 defplist parseCategory 104
5.2.7 defun parseCategory 104
5.2.8 defun parseDropAssertions 104
5.2.9 defplist parseCoerce 105
5.2.10 defun parseCoerce 105
5.2.11 defplist parseColon 105
5.2.12 defun parseColon 105
5.2.13 defplist parseDEF 106
5.2.14 defun parseDEF 106
5.2.15 defun parseLhs 107
5.2.16 defun transIs 107
5.2.17 defun transIs1 107
5.2.18 defun isListConstructor 108
5.2.19 defplist parseDollarGreaterthan 108
5.2.20 defun parseDollarGreaterThan 109
5.2.21 defplist parseDollarGreaterEqual 109
5.2.22 defun parseDollarGreaterEqual 109
5.2.23 defun parseDollarLessEqual 109
5.2.24 defplist parseDollarNotEqual 110
5.2.25 defun parseDollarNotEqual 110
5.2.26 defplist parseEquivalence 110
5.2.27 defun parseEquivalence 110
5.2.28 defplist parseExit 111
5.2.29 defun parseExit 111
5.2.30 defplist parseGreaterEqual 111
5.2.31 defun parseGreaterEqual 112
5.2.32 defplist parseGreaterThan 112
5.2.33 defun parseGreaterThan 112
5.2.34 defplist parseHas 112
5.2.35 defun parseHas 113

5.2.36 defun parseHasRhs . . . 114
5.2.37 defun loadLibIfNecessary . . . 114
5.2.38 defun updateCategoryFrameForConstructor . . . 115
5.2.39 defun convertOpAlist2compilerInfo . . . 116
5.2.40 defun updateCategoryFrameForCategory . . . 116
5.2.41 defplist parseIf . . . 117
5.2.42 defun parseIf . . . 117
5.2.43 defun parseIf,ifTran . . . 117
5.2.44 defplist parseImplies . . . 119
5.2.45 defun parseImplies . . . 120
5.2.46 defplist parseIn . . . 120
5.2.47 defun parseIn . . . 120
5.2.48 defplist parseInBy . . . 121
5.2.49 defun parseInBy . . . 121
5.2.50 defplist parseIs . . . 122
5.2.51 defun parseIs . . . 122
5.2.52 defplist parseIsnt . . . 122
5.2.53 defun parseIsnt . . . 122
5.2.54 defplist parseJoin . . . 123
5.2.55 defun parseJoin . . . 123
5.2.56 defplist parseLeave . . . 123
5.2.57 defun parseLeave . . . 123
5.2.58 defplist parseLessEqual . . . 124
5.2.59 defun parseLessEqual . . . 124
5.2.60 defplist parseLET . . . 124
5.2.61 defun parseLET . . . 124
5.2.62 defplist parseLETD . . . 125
5.2.63 defun parseLETD . . . 125
5.2.64 defplist parseMDEF . . . 125
5.2.65 defun parseMDEF . . . 126
5.2.66 defplist parseNot . . . 126
5.2.67 defplist parseNot . . . 126
5.2.68 defun parseNot . . . 126
5.2.69 defplist parseNotEqual . . . 127
5.2.70 defun parseNotEqual . . . 127
5.2.71 defplist parseOr . . . 127
5.2.72 defun parseOr . . . 127
5.2.73 defplist parsePretend . . . 128
5.2.74 defun parsePretend . . . 128
5.2.75 defplist parseReturn . . . 128
5.2.76 defun parseReturn . . . 129
5.2.77 defplist parseSegment . . . 129
5.2.78 defun parseSegment . . . 129
5.2.79 defplist parseSeq . . . 129
5.2.80 defun parseSeq . . . 130
5.2.81 defplist parseVCONS . . . 130

5.2.82 defun parseVCONS . . . 130
5.2.83 defplist parseWhere . . . 130
5.2.84 defun parseWhere . . . 131

6 Compile Transformers 133
6.0.85 defun compExpression . . . 133
6.1 Handline Category DEF forms . . . 134
6.1.1 defplist compDefine plist . . . 137
6.1.2 defun compDefine . . . 137
6.1.3 defun compDefine1 . . . 137
6.1.4 defun compDefineAddSignature . . . 139
6.1.5 defun compDefineFunctor . . . 140
6.1.6 defun compDefineFunctor1 . . . 140
6.1.7 defun compDefineCapsuleFunction . . . 147
6.1.8 defun compInternalFunction . . . 150
6.1.9 defun compDefWhereClause . . . 151
6.1.10 defun compDefineCategory . . . 153
6.1.11 defun compDefineCategory1 . . . 153
6.1.12 defun compDefineCategory2 . . . 154
6.1.13 defun compDefineLisplib . . . 157
6.1.14 defun compileDocumentation . . . 160
6.1.15 defun compArgumentConditions . . . 160
6.1.16 defun compileCases . . . 161
6.1.17 defun compFunctorBody . . . 162
6.1.18 defun compile . . . 163
6.1.19 defvar $NoValueMode . . . 165
6.1.20 defvar $EmptyMode . . . 166
6.1.21 defun hasFullSignature . . . 166
6.1.22 defun addEmptyCapsuleIfNecessary . . . 166
6.1.23 defun getTargetFromRhs . . . 166
6.1.24 defun giveFormalParametersValues . . . 167
6.1.25 defun macroExpandInPlace . . . 167
6.1.26 defun macroExpand . . . 168
6.1.27 defun macroExpandList . . . 168
6.1.28 defun makeCategoryPredicates . . . 169
6.1.29 defun mkCategoryPackage . . . 169
6.1.30 defun mkEvalableCategoryForm . . . 171
6.1.31 defun encodeFunctionName . . . 172
6.1.32 defun mkRepititionAssoc . . . 172
6.1.33 defun splitEncodedFunctionName . . . 173
6.1.34 defun encodeItem . . . 173
6.1.35 defun getCaps . . . 174
6.1.36 defun constructMacro . . . 174
6.1.37 defun spadCompileOrSetq . . . 175
6.1.38 defun compileConstructor . . . 176
6.1.39 defun compileConstructor1 . . . 176

6.1.40 defun compAndDefine . . . 177
6.1.41 defun putInLocalDomainReferences . . . 177
6.1.42 defun NRTputInTail . . . 178
6.1.43 defun NRTputInHead . . . 178
6.1.44 defun getArgumentModeOrMoan . . . 179
6.1.45 defun augLisplibModemapsFromCategory . . . 180
6.1.46 defun mkAlistOfExplicitCategoryOps . . . 181
6.1.47 defun flattenSignatureList . . . 182
6.1.48 defun interactiveModemapForm . . . 183
6.1.49 defun replaceVars . . . 184
6.1.50 defun fixUpPredicate . . . 184
6.1.51 defun orderPredicateItems . . . 185
6.1.52 defun signatureTran . . . 185
6.1.53 defun orderPredTran . . . 185
6.1.54 defun isDomainSubst . . . 188
6.1.55 defun moveORsOutside . . . 188
6.1.56 defun substVars . . . 189
6.1.57 defun modemapPattern . . . 190
6.1.58 defun evalAndRwriteLispForm . . . 191
6.1.59 defun rwriteLispForm . . . 191
6.1.60 defun mkConstructor . . . 191
6.1.61 defun unloadOneConstructor . . . 192
6.1.62 defun lisplibDoRename . . . 192
6.1.63 defun initializeLisplib . . . 192
6.1.64 defun writeLib1 . . . 193
6.1.65 defun finalizeLisplib . . . 194
6.1.66 defun getConstructorOpsAndAtts . . . 195
6.1.67 defun getCategoryOpsAndAtts . . . 196
6.1.68 defun getSlotFromCategoryForm . . . 196
6.1.69 defun transformOperationAlist . . . 196
6.1.70 defun getFunctorOpsAndAtts . . . 198
6.1.71 defun getSlotFromFunctor . . . 198
6.1.72 defun compMakeCategoryObject . . . 198
6.1.73 defun mergeSignatureAndLocalVarAlists . . . 199
6.1.74 defun lisplibWrite . . . 199
6.1.75 defun isCategoryPackageName . . . 199
6.1.76 defun NRTgetLookupFunction . . . 200
6.1.77 defun NRTgetLocalIndex . . . 201
6.1.78 defun augmentLisplibModemapsFromFunctor . . . 202
6.1.79 defun allLASSOCs . . . 203
6.1.80 defun formal2Pattern . . . 203
6.1.81 defun mkDatabasePred . . . 203
6.1.82 defun disallowNilAttribute . . . 204
6.1.83 defun bootStrapError . . . 204
6.1.84 defun reportOnFunctorCompilation . . . 204
6.1.85 defun displayMissingFunctions . . . 205

6.1.86 defun makeFunctorArgumentParameters . . . 206
6.1.87 defun genDomainViewList0 . . . 208
6.1.88 defun genDomainViewList . . . 208
6.1.89 defun genDomainView . . . 208
6.1.90 defun genDomainOps . . . 209
6.1.91 defun mkOpVec . . . 210
6.1.92 defun AssocBarGensym . . . 211
6.1.93 defun orderByDependency . . . 211
6.2 Code optimization routines . . . 212
6.2.1 defun optimizeFunctionDef . . . 212
6.2.2 defun optimize . . . 213
6.2.3 defun optXLAMCond . . . 214
6.2.4 defun optCONDtail . . . 214
6.2.5 defvar $BasicPredicates . . . 215
6.2.6 defun optPredicateIfTrue . . . 215
6.2.7 defun optIF2COND . . . 215
6.2.8 defun subrname . . . 216
6.2.9 Special case optimizers . . . 216
6.2.10 defplist optCall . . . 217
6.2.11 defun Optimize “call” expressions . . . 217
6.2.12 defun optPackageCall . . . 218
6.2.13 defun optCallSpecially . . . 218
6.2.14 defun optSpecialCall . . . 219
6.2.15 defun compileTimeBindingOf . . . 220
6.2.16 defun optCallEval . . . 221
6.2.17 defplist optSEQ . . . 221
6.2.18 defun optSEQ . . . 221
6.2.19 defplist optEQ . . . 222
6.2.20 defun optEQ . . . 223
6.2.21 defplist optMINUS . . . 223
6.2.22 defun optMINUS . . . 223
6.2.23 defplist optQSMINUS . . . 224
6.2.24 defun optQSMINUS . . . 224
6.2.25 defplist opt- . . . 224
6.2.26 defun opt- . . . 224
6.2.27 defplist optLESSP . . . 225
6.2.28 defun optLESSP . . . 225
6.2.29 defplist optSPADCALL . . . 225
6.2.30 defun optSPADCALL . . . 225
6.2.31 defplist optSuchthat . . . 226
6.2.32 defun optSuchthat . . . 226
6.2.33 defplist optCatch . . . 226
6.2.34 defun optCatch . . . 227
6.2.35 defplist optCond . . . 228
6.2.36 defun optCond . . . 228
6.2.37 defun EqualBarGensym . . . 230

6.2.38 defplist optMkRecord . . . 231
6.2.39 defun optMkRecord . . . 231
6.2.40 defplist optRECORDELT . . . 231
6.2.41 defun optRECORDELT . . . 231
6.2.42 defplist optSETRECORDELT . . . 232
6.2.43 defun optSETRECORDELT . . . 232
6.2.44 defplist optRECORDCOPY . . . 233
6.2.45 defun optRECORDCOPY . . . 233
6.3 Functions to manipulate modemaps . . . 233
6.3.1 defun addDomain . . . 233
6.3.2 defun unknownTypeError . . . 234
6.3.3 defun isFunctor . . . 234
6.3.4 defun getDomainsInScope . . . 235
6.3.5 defun putDomainsInScope . . . 236
6.3.6 defun isSuperDomain . . . 236
6.3.7 defun addNewDomain . . . 236
6.3.8 defun augModemapsFromDomain . . . 237
6.3.9 defun augModemapsFromDomain1 . . . 237
6.3.10 defun substituteCategoryArguments . . . 238
6.3.11 defun addConstructorModemaps . . . 238
6.3.12 defun getModemap . . . 239
6.3.13 defun compApplyModemap . . . 239
6.3.14 defun compMapCond . . . 241
6.3.15 defun compMapCond' . . . 241
6.3.16 defun compMapCond" . . . 241
6.3.17 defun compMapCondFun . . . 243
6.3.18 defun getUniqueSignature . . . 243
6.3.19 defun getUniqueModemap . . . 243
6.3.20 defun getModemapList . . . 243
6.3.21 defun getModemapListFromDomain . . . 244
6.3.22 defun domainMember . . . 244
6.3.23 defun augModemapsFromCategory . . . 244
6.3.24 defun addEltModemap . . . 245
6.3.25 defun mkNewModemapList . . . 246
6.3.26 defun insertModemap . . . 247
6.3.27 defun mergeModemap . . . 247
6.3.28 defun TruthP . . . 248
6.3.29 defun evalAndSub . . . 248
6.3.30 defun getOperationAlist . . . 249
6.3.31 defvar $FormalMapVariableList . . . 249
6.3.32 defun substNames . . . 250
6.3.33 defun augModemapsFromCategoryRep . . . 250
6.4 Maintaining Modemaps . . . 251
6.4.1 defun addModemapKnown . . . 251
6.4.2 defun addModemap . . . 252
6.4.3 defun addModemap0 . . . 252

6.4.4 defun addModemap1 . . . 253
6.5 Indirect called comp routines . . . 253
6.5.1 defplist compAdd plist . . . 253
6.5.2 defun compAdd . . . 254
6.5.3 defun compTuple2Record . . . 256
6.5.4 defplist compCapsule plist . . . 256
6.5.5 defun compCapsule . . . 256
6.5.6 defun compCapsuleInner . . . 257
6.5.7 defun processFunctor . . . 257
6.5.8 defun compCapsuleItems . . . 258
6.5.9 defun compSingleCapsuleItem . . . 258
6.5.10 defun doIt . . . 259
6.5.11 defun doItIf . . . 262
6.5.12 defun isMacro . . . 264
6.5.13 defplist compCase plist . . . 264
6.5.14 defun compCase . . . 265
6.5.15 defun compCase1 . . . 265
6.5.16 defplist compCat plist . . . 266
6.5.17 defplist compCat plist . . . 266
6.5.18 defplist compCat plist . . . 266
6.5.19 defun compCat . . . 266
6.5.20 defplist compCategory plist . . . 267
6.5.21 defun compCategory . . . 267
6.5.22 defun compCategoryItem . . . 268
6.5.23 defun mkExplicitCategoryFunction . . . 269
6.5.24 defun mustInstantiate . . . 270
6.5.25 defun wrapDomainSub . . . 270
6.5.26 defplist compColon plist . . . 271
6.5.27 defun compColon . . . 271
6.5.28 defun makeCategoryForm . . . 274
6.5.29 defplist compCons plist . . . 274
6.5.30 defun compCons . . . 274
6.5.31 defun compCons1 . . . 274
6.5.32 defplist compConstruct plist . . . 275
6.5.33 defun compConstruct . . . 276
6.5.34 defplist compConstructorCategory plist . . . 276
6.5.35 defplist compConstructorCategory plist . . . 277
6.5.36 defplist compConstructorCategory plist . . . 277
6.5.37 defplist compConstructorCategory plist . . . 277
6.5.38 defun compConstructorCategory . . . 277
6.5.39 defun getAbbreviation . . . 277
6.5.40 defun mkAbbrev . . . 278
6.5.41 defun addSuffix . . . 278
6.5.42 defun alistSize . . . 279
6.5.43 defun getSignatureFromMode . . . 279
6.5.44 defun getSpecialCaseAssoc . . . 280

6.5.45 defun addArgumentConditions . . . 280
6.5.46 defun stripOffSubdomainConditions . . . 281
6.5.47 defun stripOffArgumentConditions . . . 281
6.5.48 defun getSignature . . . 282
6.5.49 defun checkAndDeclare . . . 283
6.5.50 defun hasSigInTargetCategory . . . 284
6.5.51 defun getArgumentMode . . . 285
6.5.52 defplist compElt plist . . . 285
6.5.53 defun compElt . . . 285
6.5.54 defplist compExit plist . . . 286
6.5.55 defun compExit . . . 286
6.5.56 defplist compHas plist . . . 287
6.5.57 defun compHas . . . 287
6.5.58 defun compHasFormat . . . 288
6.5.59 defun mkList . . . 289
6.5.60 defplist compIf plist . . . 289
6.5.61 defun compIf . . . 289
6.5.62 defun compFromIf . . . 290
6.5.63 defun canReturn . . . 290
6.5.64 defun compBoolean . . . 292
6.5.65 defun getSuccessEnvironment . . . 293
6.5.66 defun getInverseEnvironment . . . 294
6.5.67 defun getUnionMode . . . 295
6.5.68 defun isUnionMode . . . 295
6.5.69 defplist compImport plist . . . 295
6.5.70 defun compImport . . . 296
6.5.71 defplist compIs plist . . . 296
6.5.72 defun compIs . . . 296
6.5.73 defplist compJoin plist . . . 297
6.5.74 defun compJoin . . . 297
6.5.75 defun compForMode . . . 298
6.5.76 defplist compLambda plist . . . 298
6.5.77 defun compLambda . . . 299
6.5.78 defplist compLeave plist . . . 300
6.5.79 defun compLeave . . . 300
6.5.80 defplist compMacro plist . . . 300
6.5.81 defun compMacro . . . 300
6.5.82 defplist compPretend plist . . . 301
6.5.83 defun compPretend . . . 301
6.5.84 defplist compQuote plist . . . 302
6.5.85 defun compQuote . . . 302
6.5.86 defplist compReduce plist . . . 303
6.5.87 defun compReduce . . . 303
6.5.88 defun compReduce1 . . . 303
6.5.89 defplist compRepeatOrCollect plist . . . 305
6.5.90 defplist compRepeatOrCollect plist . . . 305

6.5.91 defun compRepeatOrCollect . . . 305
6.5.92 defplist compReturn plist . . . 307
6.5.93 defun compReturn . . . 307
6.5.94 defplist compSeq plist . . . 308
6.5.95 defun compSeq . . . 308
6.5.96 defun compSeq1 . . . 308
6.5.97 defun replaceExitEtc . . . 309
6.5.98 defun convertOrCroak . . . 310
6.5.99 defun compSeqItem . . . 310
6.5.100 defplist compSetq plist . . . 310
6.5.101 defplist compSetq plist . . . 311
6.5.102 defun compSetq . . . 311
6.5.103 defun compSetq1 . . . 311
6.5.104 defun uncons . . . 312
6.5.105 defun setqMultiple . . . 312
6.5.106 defun setqMultipleExplicit . . . 314
6.5.107 defun setqSetelt . . . 315
6.5.108 defun setqSingle . . . 315
6.5.109 defun NRTassocIndex . . . 317
6.5.110 defun assignError . . . 317
6.5.111 defun outputComp . . . 318
6.5.112 defun maxSuperType . . . 318
6.5.113 defun isDomainForm . . . 319
6.5.114 defun isDomainConstructorForm . . . 319
6.5.115 defplist compString plist . . . 320
6.5.116 defun compString . . . 320
6.5.117 defplist compSubDomain plist . . . 320
6.5.118 defun compSubDomain . . . 320
6.5.119 defun compSubDomain1 . . . 321
6.5.120 defun lispize . . . 322
6.5.121 defplist compSubsetCategory plist . . . 322
6.5.122 defun compSubsetCategory . . . 322
6.5.123 defplist compSuchthat plist . . . 323
6.5.124 defun compSuchthat . . . 323
6.5.125 defplist compVector plist . . . 323
6.5.126 defun compVector . . . 324
6.5.127 defplist compWhere plist . . . 324
6.5.128 defun compWhere . . . 324
6.6 Functions for coercion . . . 325
6.6.1 defun coerce . . . 325
6.6.2 defun coerceEasy . . . 326
6.6.3 defun coerceSubset . . . 327
6.6.4 defun coerceHard . . . 327
6.6.5 defun coerceExtraHard . . . 328
6.6.6 defun hasType . . . 329
6.6.7 defun coerceable . . . 329

6.6.8 defun coerceExit . . . 330
6.6.9 defplist compAtSign plist . . . 330
6.6.10 defun compAtSign . . . 331
6.6.11 defplist compCoerce plist . . . 331
6.6.12 defun compCoerce . . . 331
6.6.13 defun compCoerce1 . . . 332
6.6.14 defun coerceByModemap . . . 332
6.6.15 defun autoCoerceByModemap . . . 333
6.6.16 defun resolve . . . 334
6.6.17 defun mkUnion . . . 335
6.6.18 defun This orders Unions . . . 335
6.6.19 defun modeEqualSubst . . . 336

7 Post Transformers 337
7.1 Direct called postparse routines . . . 337
7.1.1 defun postTransform . . . 337
7.1.2 defun postTran . . . 338
7.1.3 defun postOp . . . 339
7.1.4 defun postAtom . . . 339
7.1.5 defun postTranList . . . 339
7.1.6 defun postScriptsForm . . . 339
7.1.7 defun postTranScripts . . . 340
7.1.8 defun postTransformCheck . . . 340
7.1.9 defun postcheck . . . 341
7.1.10 defun postError . . . 341
7.1.11 defun postForm . . . 341
7.2 Indirect called postparse routines . . . 342
7.2.1 defplist postAdd plist . . . 343
7.2.2 defun postAdd . . . 343
7.2.3 defun postCapsule . . . 344
7.2.4 defun postBlockItemList . . . 344
7.2.5 defun postBlockItem . . . 344
7.2.6 defplist postAtSign plist . . . 345
7.2.7 defun postAtSign . . . 345
7.2.8 defun postType . . . 345
7.2.9 defplist postBigFloat plist . . . 346
7.2.10 defun postBigFloat . . . 346
7.2.11 defplist postBlock plist . . . 347
7.2.12 defun postBlock . . . 347
7.2.13 defplist postCategory plist . . . 347
7.2.14 defun postCategory . . . 347
7.2.15 defun postCollect,finish . . . 348
7.2.16 defun postMakeCons . . . 349
7.2.17 defplist postCollect plist . . . 349
7.2.18 defun postCollect . . . 349
7.2.19 defun postIteratorList . . . 350

7.2.20 defplist postColon plist . . . 350
7.2.21 defun postColon . . . 351
7.2.22 defplist postColonColon plist . . . 351
7.2.23 defun postColonColon . . . 351
7.2.24 defplist postComma plist . . . 352
7.2.25 defun postComma . . . 352
7.2.26 defun comma2Tuple . . . 352
7.2.27 defun postFlatten . . . 352
7.2.28 defplist postConstruct plist . . . 353
7.2.29 defun postConstruct . . . 353
7.2.30 defun postTranSegment . . . 354
7.2.31 defplist postDef plist . . . 354
7.2.32 defun postDef . . . 354
7.2.33 defun postDefArgs . . . 355
7.2.34 defplist postExit plist . . . 356
7.2.35 defun postExit . . . 356
7.2.36 defplist postIf plist . . . 356
7.2.37 defun postIf . . . 356
7.2.38 defplist postin plist . . . 357
7.2.39 defun postin . . . 357
7.2.40 defun postInSeq . . . 357
7.2.41 defplist postIn plist . . . 358
7.2.42 defun postIn . . . 358
7.2.43 defplist postJoin plist . . . 358
7.2.44 defun postJoin . . . 358
7.2.45 defplist postMapping plist . . . 359
7.2.46 defun postMapping . . . 359
7.2.47 defplist postMDef plist . . . 359
7.2.48 defun postMDef . . . 360
7.2.49 defplist postPretend plist . . . 360
7.2.50 defun postPretend . . . 361
7.2.51 defplist postQUOTE plist . . . 361
7.2.52 defun postQUOTE . . . 361
7.2.53 defplist postReduce plist . . . 361
7.2.54 defun postReduce . . . 361
7.2.55 defplist postRepeat plist . . . 362
7.2.56 defun postRepeat . . . 362
7.2.57 defplist postScripts plist . . . 362
7.2.58 defun postScripts . . . 363
7.2.59 defplist postSemiColon plist . . . 363
7.2.60 defun postSemiColon . . . 363
7.2.61 defun postFlattenLeft . . . 363
7.2.62 defplist postSignature plist . . . 364
7.2.63 defun postSignature . . . 364
7.2.64 defun removeSuperfluousMapping . . . 364
7.2.65 defun killColons . . . 365

7.2.66 defplist postSlash plist . . . 365
7.2.67 defun postSlash . . . 365
7.2.68 defplist postTuple plist . . . 365
7.2.69 defun postTuple . . . 366
7.2.70 defplist postTupleCollect plist . . . 366
7.2.71 defun postTupleCollect . . . 366
7.2.72 defplist postWhere plist . . . 366
7.2.73 defun postWhere . . . 367
7.2.74 defplist postWith plist . . . 367
7.2.75 defun postWith . . . 367
7.3 Support routines . . . 368
7.3.1 defun setDefOp . . . 368
7.3.2 defun aplTran . . . 368
7.3.3 defun aplTran1 . . . 369
7.3.4 defun aplTranList . . . 370
7.3.5 defun hasAplExtension . . . 370
7.3.6 defun deepestExpression . . . 371
7.3.7 defun containsBang . . . 371
7.3.8 defun getScriptName . . . 371
7.3.9 defun decodeScripts . . . 372

8 DEF forms 373
8.0.10 defvar $defstack . . . 373
8.0.11 defvar $is-spill . . . 373
8.0.12 defvar $is-spill-list . . . 373
8.0.13 defvar $vl . . . 373
8.0.14 defvar $is-gensymlist . . . 374
8.0.15 defvar initial-gensym . . . 374
8.0.16 defvar $is-eqlist . . . 374
8.0.17 defun hackforis . . . 374
8.0.18 defun hackforis1 . . . 374
8.0.19 defun unTuple . . . 375
8.1 The PARSE code . . . 375
8.1.1 defvar tmptok . . . 375
8.1.2 defvar tok . . . 375
8.1.3 defvar ParseMode . . . 375
8.1.4 defvar definition-name . . . 375
8.1.5 defvar lablasoc . . . 376
8.1.6 defun PARSE-NewExpr . . . 376
8.1.7 defun PARSE-Command . . . 376
8.1.8 defun PARSE-SpecialKeyWord . . . 377
8.1.9 defun PARSE-SpecialCommand . . . 377
8.1.10 defun PARSE-TokenCommandTail . . . 378
8.1.11 defun PARSE-TokenOption . . . 378
8.1.12 defun PARSE-TokenList . . . 379
8.1.13 defun PARSE-CommandTail . . . 379

8.1.14 defun PARSE-PrimaryOrQM . . . 379
8.1.15 defun PARSE-Option . . . 380
8.1.16 defun PARSE-Statement . . . 380
8.1.17 defun PARSE-InfixWith . . . 381
8.1.18 defun PARSE-With . . . 381
8.1.19 defun PARSE-Category . . . 381
8.1.20 defun PARSE-Expression . . . 382
8.1.21 defun PARSE-Import . . . 383
8.1.22 defun PARSE-Expr . . . 383
8.1.23 defun PARSE-LedPart . . . 384
8.1.24 defun PARSE-NudPart . . . 384
8.1.25 defun PARSE-Operation . . . 384
8.1.26 defun PARSE-leftBindingPowerOf . . . 385
8.1.27 defun PARSE-rightBindingPowerOf . . . 385
8.1.28 defun PARSE-getSemanticForm . . . 385
8.1.29 defun PARSE-Prefix . . . 386
8.1.30 defun PARSE-Infix . . . 386
8.1.31 defun PARSE-TokTail . . . 387
8.1.32 defun PARSE-Qualification . . . 387
8.1.33 defun PARSE-Reduction . . . 388
8.1.34 defun PARSE-ReductionOp . . . 388
8.1.35 defun PARSE-Form . . . 388
8.1.36 defun PARSE-Application . . . 389
8.1.37 defun PARSE-Label . . . 389
8.1.38 defun PARSE-Selector . . . 390
8.1.39 defun PARSE-PrimaryNoFloat . . . 390
8.1.40 defun PARSE-Primary . . . 391
8.1.41 defun PARSE-Primary1 . . . 391
8.1.42 defun PARSE-Float . . . 392
8.1.43 defun PARSE-FloatBase . . . 392
8.1.44 defun PARSE-FloatBasePart . . . 393
8.1.45 defun PARSE-FloatExponent . . . 393
8.1.46 defun PARSE-Enclosure . . . 394
8.1.47 defun PARSE-IntegerTok . . . 394
8.1.48 defun PARSE-FormalParameter . . . 395
8.1.49 defun PARSE-FormalParameterTok . . . 395
8.1.50 defun PARSE-Quad . . . 395
8.1.51 defun PARSE-String . . . 395
8.1.52 defun PARSE-VarForm . . . 396
8.1.53 defun PARSE-Scripts . . . 396
8.1.54 defun PARSE-ScriptItem . . . 396
8.1.55 defun PARSE-Name . . . 397
8.1.56 defun PARSE-Data . . . 397
8.1.57 defun PARSE-Sexpr . . . 397
8.1.58 defun PARSE-Sexpr1 . . . 398
8.1.59 defun PARSE-NBGliphTok . . . 399

8.1.60 defun PARSE-GliphTok . . . 399
8.1.61 defun PARSE-AnyId . . . 399
8.1.62 defun PARSE-Sequence . . . 400
8.1.63 defun PARSE-Sequence1 . . . 400
8.1.64 defun PARSE-OpenBracket . . . 401
8.1.65 defun PARSE-OpenBrace . . . 401
8.1.66 defun PARSE-IteratorTail . . . 402
8.1.67 defun PARSE-Iterator . . . 402
8.1.68 The PARSE implicit routines . . . 403
8.1.69 defun PARSE-Suffix . . . 403
8.1.70 defun PARSE-SemiColon . . . 403
8.1.71 defun PARSE-Return . . . 404
8.1.72 defun PARSE-Exit . . . 404
8.1.73 defun PARSE-Leave . . . 404
8.1.74 defun PARSE-Seg . . . 405
8.1.75 defun PARSE-Conditional . . . 405
8.1.76 defun PARSE-ElseClause . . . 406
8.1.77 defun PARSE-Loop . . . 406
8.1.78 defun PARSE-LabelExpr . . . 407
8.1.79 defun PARSE-FloatTok . . . 407
8.2 The PARSE support routines . . . 407
8.2.1 String grabbing . . . 408
8.2.2 defun match-string . . . 408
8.2.3 defun skip-blanks . . . 408
8.2.4 defun token-lookahead-type . . . 409
8.2.5 defun match-advance-string . . . 409
8.2.6 defun initial-substring-p . . . 410
8.2.7 defun quote-if-string . . . 410
8.2.8 defun escape-keywords . . . 411
8.2.9 defun isTokenDelimiter . . . 411
8.2.10 defun underscore . . . 411
8.2.11 Token Handling . . . 412
8.2.12 defun getToken . . . 412
8.2.13 defun unget-tokens . . . 412
8.2.14 defun match-current-token . . . 413
8.2.15 defun match-token . . . 413
8.2.16 defun match-next-token . . . 413
8.2.17 defun current-symbol . . . 414
8.2.18 defun make-symbol-of . . . 414
8.2.19 defun current-token . . . 414
8.2.20 defun try-get-token . . . 414
8.2.21 defun next-token . . . 415
8.2.22 defun advance-token . . . 415
8.2.23 defvar XTokenReader . . . 416
8.2.24 defun get-token . . . 416
8.2.25 Character handling . . . 416

8.2.26 defun current-char . . . 416
8.2.27 defun next-char . . . 416
8.2.28 defun char-eq . . . 417
8.2.29 defun char-ne . . . 417
8.2.30 Error handling . . . 417
8.2.31 defvar meta-error-handler . . . 417
8.2.32 defun meta-syntax-error . . . 417
8.2.33 Floating Point Support . . . 418
8.2.34 defun floatexpid . . . 418
8.2.35 Dollar Translation . . . 418
8.2.36 defun dollarTran . . . 418
8.2.37 Applying metagrammatical elements of a production (e.g., Star). . . . 418
8.2.38 defmacro Bang . . . 419
8.2.39 defmacro must . . . 419
8.2.40 defun action . . . 419
8.2.41 defun optional . . . 419
8.2.42 defmacro star . . . 420
8.2.43 Stacking and retrieving reductions of rules. . . . 420
8.2.44 defvar reduce-stack . . . 420
8.2.45 defmacro reduce-stack-clear . . . 420
8.2.46 defun push-reduction . . . 421

9 Comment Recording 423
9.1 Comment Recording Layer 0 – API . . . 424
9.1.1 defun recordSignatureDocumentation . . . 424
9.1.2 defun recordAttributeDocumentation . . . 424
9.2 Comment Recording Layer 1 . . . 424
9.2.1 defun recordDocumentation . . . 424
9.3 Comment Recording Layer 2 . . . 425
9.3.1 defun collectComBlock . . . 425
9.4 Comment Recording Layer 3 . . . 425
9.4.1 defun recordHeaderDocumentation . . . 425
9.4.2 defun collectAndDeleteAssoc . . . 426

10 Category handling 427
10.0.3 defun getConstructorExports . . . 427

11 Building libdb.text 429
11.0.4 defun extendLocalLibdb . . . 429
11.0.5 defun buildLibdb . . . 430
11.0.6 defun buildLibdbString . . . 432
11.0.7 defun dbReadLines . . . 432
11.0.8 defun purgeNewConstructorLines . . . 432
11.0.9 defun dbWriteLines . . . 433
11.0.10 defun buildLibdbConEntry . . . 433
11.0.11 defun buildLibOps . . . 435

11.0.12 defun buildLibOp . . . 435
11.0.13 defun buildLibAttrs . . . 436
11.0.14 defun buildLibAttr . . . 436
11.0.15 defun screenLocalLine . . . 437

12 Comment Syntax Checking 439
12.1 Comment Checking Layer 0 – API . . . 444
12.1.1 defun finalizeDocumentation . . . 444
12.2 Comment Checking Layer 1 . . . 446
12.2.1 defun transDocList . . . 446
12.3 Comment Checking Layer 2 . . . 447
12.3.1 defun transDoc . . . 447
12.4 Comment Checking Layer 3 . . . 448
12.4.1 defun transformAndRecheckComments . . . 448
12.5 Comment Checking Layer 4 . . . 449
12.5.1 defun checkComments . . . 449
12.5.2 defun checkRewrite . . . 450
12.6 Comment Checking Layer 5 . . . 451
12.6.1 defun checkArguments . . . 451
12.6.2 defun checkBalance . . . 452
12.7 Comment Checking Layer 6 . . . 453
12.7.1 defun checkBeginEnd . . . 453
12.7.2 defun checkDecorate . . . 454
12.7.3 defun checkDecorateForHt . . . 456
12.7.4 defun checkDocError1 . . . 457
12.7.5 defun checkFixCommonProblem . . . 457
12.7.6 defun checkGetLispFunctionName . . . 458
12.7.7 defun checkHTargs . . . 458
12.7.8 defun checkRecordHash . . . 459
12.7.9 defun spadSysChoose . . . 461
12.7.10 defun spadSysBranch . . . 462
12.7.11 defun checkTexht . . . 462
12.7.12 defun checkTransformFirsts . . . 463
12.7.13 defun checkTrim . . . 466
12.8 Comment Checking Layer 7 . . . 467
12.8.1 defun checkDocError . . . 467
12.8.2 defun checkRemoveComments . . . 467
12.8.3 defun checkSkipToken . . . 468
12.8.4 defun checkSplit2Words . . . 468
12.9 Comment Checking Layer 8 . . . 469
12.9.1 defun checkAddIndented . . . 469
12.9.2 defun checkDocMessage . . . 469
12.9.3 defun checkExtract . . . 469
12.9.4 defun checkGetArgs . . . 470
12.9.5 defun checkGetMargin . . . 471
12.9.6 defun checkGetParse . . . 471

12.9.7 defun checkGetStringBeforeRightBrace . . . 472
12.9.8 defun checkIeEg . . . 472
12.9.9 defun checkIndentedLines . . . 473
12.9.10 defun checkSkipIdentifierToken . . . 474
12.9.11 defun checkSkipOpToken . . . 474
12.9.12 defun checkSplitBrace . . . 474
12.9.13 defun checkTrimCommented . . . 475
12.9.14 defun newString2Words . . . 475
12.10 Comment Checking Layer 9 . . . 476
12.10.1 defun checkAddBackSlashes . . . 476
12.10.2 defun checkAddMacros . . . 477
12.10.3 defun checkAddPeriod . . . 477
12.10.4 defun checkAddSpaceSegments . . . 478
12.10.5 defun checkAddSpaces . . . 478
12.10.6 defun checkAlphabetic . . . 479
12.10.7 defun checkIeEgfun . . . 479
12.10.8 defun checkIsValidType . . . 480
12.10.9 defun checkLookForLeftBrace . . . 481
12.10.10 defun checkLookForRightBrace . . . 481
12.10.11 defun checkNumOfArgs . . . 481
12.10.12 defun checkSayBracket . . . 482
12.10.13 defun checkSkipBlanks . . . 482
12.10.14 defun checkSplitBackslash . . . 482
12.10.15 defun checkSplitOn . . . 483
12.10.16 defun checkSplitPunctuation . . . 484
12.10.17 defun firstNonBlankPosition . . . 485
12.10.18 defun getMatchingRightPren . . . 485
12.10.19 defun hasNoVowels . . . 486
12.10.20 defun htcharPosition . . . 486
12.10.21 defun newWordFrom . . . 487
12.10.22 defun removeBackslashes . . . 487
12.10.23 defun whoOwns . . . 488

13 Utility Functions **489**
13.0.24 defun translabel . . . 489
13.0.25 defun translabel1 . . . 489
13.0.26 defun displayPreCompilationErrors . . . 490
13.0.27 defun bumperrorcount . . . 490
13.0.28 defun parseTranCheckForRecord . . . 491
13.0.29 defun makeSimplePredicateOrNil . . . 491
13.0.30 defun parse-spadstring . . . 492
13.0.31 defun parse-string . . . 492
13.0.32 defun parse-identifier . . . 492
13.0.33 defun parse-number . . . 493
13.0.34 defun parse-keyword . . . 493
13.0.35 defun parse-argument-designator . . . 493

13.0.36 defun checkWarning . . . 494
13.0.37 defun tuple2List . . . 494
13.0.38 defmacro pop-stack-1 . . . 495
13.0.39 defmacro pop-stack-2 . . . 495
13.0.40 defmacro pop-stack-3 . . . 495
13.0.41 defmacro pop-stack-4 . . . 496
13.0.42 defmacro nth-stack . . . 496
13.0.43 defun Pop-Reduction . . . 496
13.0.44 defun addclose . . . 496
13.0.45 defun blankp . . . 497
13.0.46 defun drop . . . 497
13.0.47 defun escaped . . . 497
13.0.48 defvar $comblocklist . . . 498
13.0.49 defun fincomblock . . . 498
13.0.50 defun indent-pos . . . 498
13.0.51 defun infixtok . . . 499
13.0.52 defun is-console . . . 499
13.0.53 defun next-tab-loc . . . 499
13.0.54 defun nonblankloc . . . 500
13.0.55 defun parseprint . . . 500
13.0.56 defun skip-to-endif . . . 500

14 The Compiler **501**
14.0.57 defvar $newConlist . . . 501
14.1 Compiling EQ.spad . . . 501
14.2 The top level compiler command . . . 504
14.2.1 defun compiler . . . 505
14.2.2 defun compileSpad2Cmd . . . 507
14.2.3 defun compileSpadLispCmd . . . 510
14.2.4 compilerDoitWithScreenedLisplib . . . 511
14.2.5 defun compilerDoit . . . 512
14.2.6 defun /rq . . . 513
14.2.7 defun /rf . . . 513
14.2.8 defun /RQ,LIB . . . 513
14.2.9 defun /rf-1 . . . 514
14.2.10 defun spad . . . 515
14.2.11 defun Interpreter interface to the compiler . . . 517
14.2.12 defun compTopLevel . . . 526
14.2.13 defun print-defun . . . 527
14.2.14 defun def-rename . . . 527
14.2.15 defun compOrCroak . . . 528
14.2.16 defun compOrCroak1 . . . 529
14.2.17 defun comp . . . 530
14.2.18 defun compNoStacking . . . 530
14.2.19 defun compNoStacking1 . . . 531
14.2.20 defun comp2 . . . 531

14.2.21 defun comp3 . . . 532
14.2.22 defun applyMapping . . . 533
14.2.23 defun compApply . . . 534
14.2.24 defun compTypeOf . . . 535
14.2.25 defun compColonInside . . . 536
14.2.26 defun compAtom . . . 536
14.2.27 defun compAtomWithModemap . . . 537
14.2.28 defun transImplementation . . . 538
14.2.29 defun convert . . . 538
14.2.30 defun primitiveType . . . 539
14.2.31 defun compSymbol . . . 539
14.2.32 defun compList . . . 540
14.2.33 defun compForm . . . 541
14.2.34 defun compForm1 . . . 541
14.2.35 defun compToApply . . . 543
14.2.36 defun compApplication . . . 544
14.2.37 defun getFormModemaps . . . 545
14.2.38 defun eltModemapFilter . . . 546
14.2.39 defun seteltModemapFilter . . . 547
14.2.40 defun compExpressionList . . . 547
14.2.41 defun compForm2 . . . 548
14.2.42 defun compForm3 . . . 550
14.2.43 defun compFocompFormWithModemap . . . 550
14.2.44 defun substituteIntoFunctorModemap . . . 552
14.2.45 defun compFormPartiallyBottomUp . . . 552
14.2.46 defun compFormMatch . . . 553
14.2.47 defun compUniquely . . . 553
14.2.48 defun compArgumentsAndTryAgain . . . 553
14.2.49 defun compWithMappingMode . . . 554
14.2.50 defun compWithMappingMode1 . . . 554
14.2.51 defun extractCodeAndConstructTriple . . . 559
14.2.52 defun hasFormalMapVariable . . . 560
14.2.53 defun argsToSig . . . 560
14.2.54 defun compMakeDeclaration . . . 561
14.2.55 defun modifyModeStack . . . 561
14.2.56 defun Create a list of unbound symbols . . . 562
14.2.57 defun compOrCroak1,compactify . . . 563
14.2.58 defun Compiler/Interpreter interface . . . 563
14.2.59 defun recompile-lib-file-if-necessary . . . 563
14.2.60 defun spad-fixed-arg . . . 564
14.2.61 defun compile-lib-file . . . 564
14.2.62 defun compileFileQuietly . . . 564
14.2.63 defvar $byConstructors . . . 565
14.2.64 defvar $constructorsSeen . . . 565

15 Level 1 **567**
15.0.65 defvar current-fragment 567
15.0.66 defun read-a-line 567

16 The Chunks **569**

Signatures **583**

Bibliography **585**

Index **589**

Volume 10: Axiom Algebra: Implementation

1 The Algebra Makefile **1**
1.1 Adding new algebra . . . 1
1.2 Adding the algebra to the proper book . . . 2
1.2.1 Adding a Category . . . 2
1.2.2 Adding a Domain . . . 2
1.2.3 Adding a Package . . . 8
1.2.4 Adding Numerics . . . 8
1.3 Rebuilding the algebra from scratch . . . 8
1.4 The Algebra Lattice Layers . . . 9
1.4.1 Layer 0 Bootstrap . . . 9
1.4.2 Layer 0 . . . 11
1.4.3 Layer 1 . . . 15
1.4.4 Layer 2 . . . 24
1.4.5 Layer 3 . . . 33
1.4.6 Layer 4 . . . 37
1.4.7 Layer 5 . . . 39
1.4.8 Layer6 . . . 43
1.4.9 Layer7 . . . 52
1.4.10 Layer8 . . . 79
1.4.11 Layer9 . . . 94
1.4.12 Layer10 . . . 100
1.4.13 Layer11 . . . 112
1.4.14 Layer12 . . . 181
1.4.15 Layer13 . . . 189
1.4.16 Layer14 . . . 194
1.4.17 Layer15 . . . 203
1.4.18 Layer16 . . . 207
1.4.19 Layer17 . . . 245
1.4.20 Layer18 . . . 297
1.4.21 Layer19 . . . 313
1.4.22 Layer20 . . . 318
1.4.23 Layer21 . . . 319
1.4.24 Layer22 . . . 321
1.4.25 Layer23 . . . 322
1.4.26 Order . . . 323
1.5 Cliques . . . 324
1.6 Broken Files . . . 325
1.7 The Environment . . . 325
1.7.1 The working directories . . . 325
1.7.2 The depsys variable . . . 326
1.7.3 The interpsys variable . . . 326
1.7.4 The shell variable . . . 326
1.8 The Makefile Stanzas . . . 327

1.9 Generic Make Rules . . . 328
1.10 Pamphlet file structure . . . 330
1.10.1 Finding the algebra code . . . 331
1.10.2 Write the Makefile stanzas for the algebra files . . . 331
1.10.3 Find the algebra bootstrap code . . . 333
1.10.4 Write the Makefile stanzas for the bootstrap files . . . 333
1.11 Stage markers . . . 334
1.11.1 Regression testing . . . 336
1.12 The Makefile . . . 359

2 Algebra Background **363**
2.1 How NAG Libraries were used . . . 365
2.2 Algebraic Function Fields and Algebraic Geometry . . . 365
2.2.1 The Genus of a Plane Curve . . . 366
2.2.2 Algebraic Curves with PAFF . . . 372
2.2.3 Algebraic Curves with PAFFFF . . . 376
2.3 Groebner Basis . . . 384
2.3.1 How To Compute A Groebner Basis . . . 385
2.3.2 Monomial Ordering . . . 386
2.3.3 Variable Ordering . . . 387
2.3.4 Combined Ordering . . . 387
2.3.5 An Example Computation . . . 387
2.4 Elementary Functions . . . 390
2.4.1 Rationale for Branch Cuts and Identities . . . 390
2.4.2 Inverse trigonometric functions . . . 392
2.4.3 Inverse hyperbolic functions . . . 393

Bibliography **395**

Volume 10.1: Axiom Algebra: Theory

1 Interval Arithmetic **1**
1.1 Addition . . . 1
1.2 Sign Change . . . 2
1.3 Subtraction . . . 2
1.4 Multiplication . . . 2
1.5 Multiplication by a positive number . . . 2
1.6 Multiplication of Two Positive Numbers . . . 3
1.7 Division . . . 3
1.8 Reciprocal . . . 3
1.9 Absolute Value . . . 3
1.10 Square . . . 4
1.11 Square Root . . . 4

2 Integration **5**
2.1 Rational Functions . . . 6
2.1.1 The full partial-fraction algorithm . . . 6
2.1.2 The Hermite reduction . . . 7
2.1.3 The Rothstein-Trager and Lazard-Rioboo-Trager algorithms . . . 8
2.2 Algebraic Functions . . . 9
2.2.1 The Hermite reduction . . . 10
2.2.2 Simple radical extensions . . . 13
2.2.3 Liouville's Theorem . . . 14
2.2.4 The integral part . . . 15
2.2.5 The logarithmic part . . . 16
2.3 Elementary Functions . . . 19
2.3.1 Differential algebra . . . 19
2.3.2 The Hermite reduction . . . 20
2.3.3 The polynomial reduction . . . 21
2.3.4 The residue criterion . . . 22
2.3.5 The transcendental logarithmic case . . . 24
2.3.6 The transcendental exponential case . . . 24
2.3.7 The transcendental tangent case . . . 25
2.3.8 The algebraic logarithmic case . . . 26
2.3.9 The algebraic exponential case . . . 28

3 Singular Value Decomposition **31**
3.1 Singular Value Decomposition Tutorial . . . 31

4 Quaternions **37**
Preface . . . 37
4.1 Quaternions . . . 38
4.2 Vectors, and their Composition . . . 38
4.3 Examples To Chapter 1. . . . 62

4.4 Products And Quotients of Vectors . . . 64
4.5 Examples To Chapter 2. . . . 89
4.6 Interpretations And Transformations . . . 90
4.7 Examples to Chapter 3 . . . 117
4.8 Axiom Examples . . . 122

5 Clifford Algebra 125
5.1 Introduction . . . 125
5.2 Clifford Basis Matrix Theory . . . 125
5.3 Calculation of the inverse of a Clifford number . . . 128
5.3.1 Example 1: Clifford (2) . . . 128
5.3.2 Example 2: Clifford (3) . . . 129
5.3.3 Example 3: Clifford (2,2) . . . 131
5.3.4 Conclusion . . . 134

6 Package for Algebraic Function Fields 135

7 Interpolation Formulas 137

8 Type Systems 141
8.1 Prelude . . . 146
8.1.1 Terminology . . . 146
8.1.2 General Notation . . . 149
8.1.3 Partial Orders and Quasi-Lattices . . . 149
8.1.4 Order-Sorted Algebras . . . 151
8.1.5 Category Theory . . . 154
8.1.6 The Type System of Axiom . . . 155
8.2 Type Classes . . . 157
8.2.1 Types as Terms of an Order-Sorted Signature . . . 157
8.2.2 Type Inference . . . 161
8.2.3 Complexity of Type Inference . . . 167
8.2.4 Algebraic Specifications of Type Classes . . . 168
8.2.5 Parameterized Type Classes . . . 171
8.2.6 Type Classes as First-Order Types . . . 173
8.3 Coercions . . . 177
8.3.1 General Remarks . . . 177
8.3.2 Coherence . . . 177
8.3.3 Type Isomorphisms . . . 185
8.3.4 A Type Coercion Problem . . . 189
8.3.5 Properties of the Coercion Preorder . . . 192
8.3.6 Combining Type Classes and Coercions . . . 194
8.3.7 Type Inference . . . 198
8.4 Other Typing Constructs . . . 205
8.4.1 Partial Functions . . . 205
8.4.2 Types Depending on Elements . . . 206

9 Type Systems 2 **211**
9.0.3 Object in Computer Algebra . . . 214
9.0.4 Multiple Representations . . . 215
9.0.5 Domains and Categories . . . 217
9.0.6 Domain Sharing . . . 221
9.0.7 Packages and Categories . . . 222
9.0.8 Parameterization . . . 223
9.0.9 Subtyping of Domains . . . 230
9.0.10 Type Classes . . . 233
9.0.11 Comparison with Related Work . . . 236
9.0.12 Conclusions . . . 238

10 Doye's Coercion Algorithm **241**
10.1 Introduction . . . 241
10.1.1 Abstract Datatypes in General . . . 241
10.1.2 The Problem . . . 242
10.1.3 Examples of how Axiom coerces . . . 243
10.1.12 Mathematical solution overview . . . 244
10.1.13 Constructing coercions algorithmically . . . 245
10.2 Types in Computer Algebra . . . 246
10.2.1 Introduction . . . 246
10.3 Category Theory . . . 248
10.3.1 About Category Theory . . . 248
10.3.17 Categories and Axiom . . . 251
10.3.19 Functors and Axiom . . . 252
10.3.20 Coercion and category theory . . . 252
10.3.21 Conclusion . . . 252
10.4 Order sorted algebra . . . 252
10.4.1 Universal Algebra . . . 253
10.4.13 Term Algebras . . . 255
10.4.16 Order-sorted algebras . . . 255
10.4.24 Extension of signatures . . . 257
10.4.28 The equational calculus . . . 258
10.4.48 Signatures, theories, varieties, and Axiom . . . 261
10.4.49 Conclusion . . . 262
10.5 Extending order sorted algebra . . . 262
10.5.1 Partial Functions . . . 263
10.5.10 Conditional varieties . . . 266
10.5.22 A Category theory approach . . . 270
10.5.23 Coercion . . . 270
10.5.26 Conclusion . . . 272
10.6 Coherence . . . 272
10.6.1 Weber's work I: definitions . . . 272
10.6.10 Weber's work II: Assumptions and a conjecture . . . 275
10.6.18 The coherence theorem . . . 277
10.6.26 Extending the coherence theorem . . . 287

10.6.31 Conclusion . . . 290
10.7 The automated coercion algorithm . . . 290
10.7.1 Finitely generated algebras . . . 290
10.7.5 Constructibility . . . 291
10.7.10 The algorithm . . . 294
10.7.12 Existence of the coercion . . . 296
10.7.13 Proving homomorphicity and coerciveness . . . 297
10.7.22 Conclusion . . . 300
10.8 Implementation Details . . . 300
10.8.1 Labelling operstors . . . 300
10.8.2 Getting information from domains . . . 301
10.8.3 Checking information from domains . . . 301
10.8.4 Flaws in the implementation . . . 301
10.8.5 Conclusion . . . 303
10.9 Making Axiom algebraically correct . . . 303
10.9.1 Explicitly defined theories . . . 303
10.9.2 Operator symbols and names . . . 303
10.9.3 Moving certain operators . . . 306
10.9.4 Retyping certain sorts . . . 307
10.9.5 Sorts and their order . . . 308
10.9.6 Altering Axiom's databases . . . 309
10.9.7 Conclusion . . . 309
10.10 Conclusions . . . 310
10.10.1 Summary . . . 310
10.10.2 Future work and extensions . . . 311

11 Symmetries of Partial Differential Equations 313
11.1 Symmetries of Differential Equations and the Scratchpad Package SPDE . . . 313

12 Primality Testing Revisited by James Davenport 319
12.1 Rabin revisited . . . 320
12.2 Non-square-free numbers . . . 322
12.3 Jaeschke analysed . . . 322
12.4 Roots of -1 . . . 323
12.5 The "maximial 2-part" test . . . 324
12.6 How would one defeat these modifications? . . . 326
12.7 Leech's attack . . . 326
12.8 The $(K+1)\cdot(2K+1)$ attack . . . 327
12.9 Conclusions . . . 329

13 Finite Fields in Axiom (Grabmeier/Scheerhorn) 333
13.1 Basic theory and notations . . . 334
13.2 Categories for finite field domains . . . 336
13.3 General finite field functions . . . 336
13.3.1 E as an algebra of rank n over F . . . 337
13.3.2 The $F[X]$-module structure of E . . . 338

13.3.3 The cyclic group E^* . . . 339
13.3.4 Discrete logarithm . . . 339
13.3.5 Elements of maximal order . . . 340
13.3.6 Enumeration of elements of E . . . 341
13.3.7 Conversion between elements of the field and its groundfield . . . 341
13.4 Prime field . . . 341
13.4.1 Extension Constructors of Finite Fields . . . 342
13.5 Polynomial basis representation . . . 343
13.6 Cyclic group representation . . . 343
13.6.1 Operations of multiplicative nature . . . 344
13.6.2 Addition and Zech logarithm . . . 345
13.6.3 Time expensive operations . . . 346
13.7 Normal basis representation . . . 346
13.7.1 Operations of additive nature . . . 347
13.7.2 Multiplication and normal basis complexity . . . 348
13.7.3 Norm and multiplicative inverse . . . 349
13.7.4 Exponentiation . . . 350
13.8 Homomorphisms between finite fields . . . 351
13.8.1 Basis change between normal and polynomial basis representation . . . 352
13.8.2 Conversion between different extensions . . . 353
13.9 Polynomials over finite fields . . . 354
13.9.1 Root finding . . . 354
13.9.2 Polynomials with certain properties . . . 354
13.9.3 Testing whether a polynomial is of a given kind . . . 355
13.9.4 Searching the next polynomial of a given kind . . . 355
13.9.5 Creating polynomials . . . 356
13.9.6 Number of polynomials of a given kind and degree . . . 357
13.9.7 Some other functions concerning polynomials . . . 357
13.10 Future directions . . . 358
13.11 Comparison of computation times between different representations . . . 358
13.11.1 The extension fields $GF(5^4)$ over $GF(5)$ and $GF(2^{10})$ over $GF(2)$ . . . 358
13.11.2 Different extensions of $GF(5^{21})$ over $GF(5)$ . . . 359
13.12 Dependencies between the constructors . . . 360

14 Real Quantifier Elimination **361**
14.1 Overview . . . 361
14.2 General Methods . . . 362
14.2.1 The First Method . . . 362
14.2.2 Cylindrical Algebraic Decomposition Method . . . 366
14.2.3 Quantifier-Block Elimination Methods . . . 373
14.3 Special Methods . . . 378
14.3.1 Low Degrees . . . 378
14.3.2 Constrained by Quadratic Equation . . . 381
14.3.3 Single Atomic Formula . . . 384
14.4 Approximate Methods . . . 387
14.4.1 Generic Quantifier Elimination . . . 387

14.4.2 Volume Approximate Quantifier Elimination 391

15 Potential Future Algebra **401**

16 Groebner Basis by Siddharth Bhat **403**
16.1 A Grobner Basis example 403
16.1.1 What the hell is Grobner Basis? 404
16.1.2 A complicated example that shattters dreams 404
16.1.3 An explanation through a slightly simpler problem 405
16.2 Ideals as Rewrite Systems 409
16.2.1 A motivating example 409
16.2.2 The rewrite rule perspective 409
16.2.3 Buchberger's algorithm 410

17 Greatest Common Divisor **411**

18 Polynomial Factorization **413**

19 Differential Forms **415**
19.1 From differentials to differential forms 415
19.1.1 The wedge product 416
19.1.2 The exterior derivative 419
19.1.3 The Hodge dual 421

20 Pade approximant **423**

21 Schwartz-Zippel lemma **425**

22 Chinese Remainder Theorem **427**

23 Gaussian Elimination **429**

24 Diophantine Equations **431**

Bibliography **433**

Index **505**

Volume 10.2: Axiom Algebra: Categories

1 Categories **1**

2 Category Layer 1 **3**
2.0.1 Category (CATEGORY) . . . 3
2.0.2 AdditiveValuationAttribute (ATADDVA) . . . 5
2.0.3 ApproximateAttribute (ATAPPRO) . . . 7
2.0.4 ArbitraryExponentAttribute (ATARBEX) . . . 9
2.0.5 ArbitraryPrecisionAttribute (ATARBPR) . . . 11
2.0.6 ArcHyperbolicFunctionCategory (AHYP) . . . 13
2.0.7 ArcTrigonometricFunctionCategory (ATRIG) . . . 16
2.0.8 AttributeRegistry (ATTREG) . . . 20
2.0.9 BasicType (BASTYPE) . . . 27
2.0.10 CanonicalAttribute (ATCANON) . . . 30
2.0.11 CanonicalClosedAttribute (ATCANCL) . . . 32
2.0.12 CanonicalUnitNormalAttribute (ATCUNOR) . . . 34
2.0.13 CentralAttribute (ATCENRL) . . . 36
2.0.14 CoercibleTo (KOERCE) . . . 39
2.0.15 CombinatorialFunctionCategory (CFCAT) . . . 42
2.0.16 CommutativeStarAttribute (ATCS) . . . 45
2.0.17 ConvertibleTo (KONVERT) . . . 47
2.0.18 ElementaryFunctionCategory (ELEMFUN) . . . 51
2.0.19 Eltable (ELTAB) . . . 54
2.0.20 FiniteAggregateAttribute (ATFINAG) . . . 57
2.0.21 HyperbolicFunctionCategory (HYPCAT) . . . 59
2.0.22 InnerEvalable (IEVALAB) . . . 64
2.0.23 JacobiIdentityAttribute (ATJACID) . . . 68
2.0.24 LazyRepresentationAttribute (ATLR) . . . 70
2.0.25 LeftUnitaryAttribute (ATLUNIT) . . . 72
2.0.26 ModularAlgebraicGcdOperations (MAGCDOC) . . . 74
2.0.27 MultiplicativeValuationAttribute (ATMULVA) . . . 79
2.0.28 NotherianAttribute (ATNOTHR) . . . 81
2.0.29 NoZeroDivisorsAttribute (ATNZDIV) . . . 83
2.0.30 NullSquareAttribute (ATNULSQ) . . . 86
2.0.31 OpenMath (OM) . . . 88
2.0.32 PartiallyOrderedSetAttribute (ATPOSET) . . . 91
2.0.33 PartialTranscendentalFunctions (PTRANFN) . . . 94
2.0.34 Patternable (PATAB) . . . 100
2.0.35 PrimitiveFunctionCategory (PRIMCAT) . . . 104
2.0.36 RadicalCategory (RADCAT) . . . 106
2.0.37 RetractableTo (RETRACT) . . . 110
2.0.38 RightUnitaryAttribute (ATRUNIT) . . . 114
2.0.39 ShallowlyMutableAttribute (ATSHMUT) . . . 117
2.0.40 SpecialFunctionCategory (SPFCAT) . . . 119

2.0.41 TrigonometricFunctionCategory (TRIGCAT) . . . 123
2.0.42 Type (TYPE) . . . 127
2.0.43 UnitsKnownAttribute (ATUNIKN) . . . 130

3 Category Layer 2 **133**
3.0.44 Aggregate (AGG) . . . 133
3.0.45 CombinatorialOpsCategory (COMBOPC) . . . 138
3.0.46 Comparable (COMPAR) . . . 142
3.0.47 EltableAggregate (ELTAGG) . . . 146
3.0.48 Evalable (EVALAB) . . . 151
3.0.49 FortranProgramCategory (FORTCAT) . . . 155
3.0.50 FullyRetractableTo (FRETRCT) . . . 158
3.0.51 FullyPatternMatchable (FPATMAB) . . . 164
3.0.52 Logic (LOGIC) . . . 168
3.0.53 PlottablePlaneCurveCategory (PPCURVE) . . . 172
3.0.54 PlottableSpaceCurveCategory (PSCURVE) . . . 176
3.0.55 RealConstant (REAL) . . . 180
3.0.56 SegmentCategory (SEGCAT) . . . 183
3.0.57 SetCategory (SETCAT) . . . 187
3.0.58 TranscendentalFunctionCategory (TRANFUN) . . . 192

4 Category Layer 3 **201**
4.0.59 AbelianSemiGroup (ABELSG) . . . 201
4.0.60 BlowUpMethodCategory (BLMETCT) . . . 206
4.0.61 DesingTreeCategory (DSTRCAT) . . . 210
4.0.62 FortranFunctionCategory (FORTFN) . . . 219
4.0.63 FortranMatrixCategory (FMC) . . . 225
4.0.64 FortranMatrixFunctionCategory (FMFUN) . . . 229
4.0.65 FortranVectorCategory (FVC) . . . 236
4.0.66 FortranVectorFunctionCategory (FVFUN) . . . 240
4.0.67 FullyEvalableOver (FEVALAB) . . . 246
4.0.68 FileCategory (FILECAT) . . . 252
4.0.69 Finite (FINITE) . . . 258
4.0.70 FileNameCategory (FNCAT) . . . 263
4.0.71 GradedModule (GRMOD) . . . 269
4.0.72 LeftOreRing (LORER) . . . 274
4.0.73 HomogeneousAggregate (HOAGG) . . . 280
4.0.74 IndexedDirectProductCategory (IDPC) . . . 290
4.0.75 LiouvillianFunctionCategory (LFCAT) . . . 295
4.0.76 Monad (MONAD) . . . 303
4.0.77 NumericalIntegrationCategory (NUMINT) . . . 309
4.0.78 NumericalOptimizationCategory (OPTCAT) . . . 315
4.0.79 OrdinaryDifferentialEquationsSolverCategory (ODECAT) . . . 321
4.0.80 OrderedSet (ORDSET) . . . 326
4.0.81 PartialDifferentialEquationsSolverCategory (PDECAT) . . . 331
4.0.82 PatternMatchable (PATMAB) . . . 337

4.0.83 RealRootCharacterizationCategory (RRCC) . . . 341
4.0.84 SegmentExpansionCategory (SEGXCAT) . . . 348
4.0.85 SemiGroup (SGROUP) . . . 353
4.0.86 SetCategoryWithDegree (SETCATD) . . . 358
4.0.87 SExpressionCategory (SEXCAT) . . . 361
4.0.88 StepThrough (STEP) . . . 367
4.0.89 ThreeSpaceCategory (SPACEC) . . . 371

5 Category Layer 4 383
5.0.90 AbelianMonoid (ABELMON) . . . 383
5.0.91 AffineSpaceCategory (AFSPCAT) . . . 388
5.0.92 BagAggregate (BGAGG) . . . 393
5.0.93 CachableSet (CACHSET) . . . 399
5.0.94 Collection (CLAGG) . . . 403
5.0.95 DifferentialVariableCategory (DVARCAT) . . . 411
5.0.96 ExpressionSpace (ES) . . . 418
5.0.97 GradedAlgebra (GRALG) . . . 436
5.0.98 IndexedAggregate (IXAGG) . . . 441
5.0.99 MonadWithUnit (MONADWU) . . . 449
5.0.100 Monoid (MONOID) . . . 455
5.0.101 OrderedFinite (ORDFIN) . . . 461
5.0.102 PlacesCategory (PLACESC) . . . 464
5.0.103 ProjectiveSpaceCategory (PRSPCAT) . . . 469
5.0.104 RecursiveAggregate (RCAGG) . . . 475
5.0.105 TwoDimensionalArrayCategory (ARR2CAT) . . . 481

6 Category Layer 5 497
6.0.106 BinaryRecursiveAggregate (BRAGG) . . . 498
6.0.107 CancellationAbelianMonoid (CABMON) . . . 508
6.0.108 DictionaryOperations (DIOPS) . . . 512
6.0.109 DoublyLinkedAggregate (DLAGG) . . . 519
6.0.110 Group (GROUP) . . . 525
6.0.111 LinearAggregate (LNAGG) . . . 531
6.0.112 MatrixCategory (MATCAT) . . . 540
6.0.113 OrderedAbelianSemiGroup (OASGP) . . . 590
6.0.114 OrderedMonoid (ORDMON) . . . 594
6.0.115 PolynomialSetCategory (PSETCAT) . . . 598
6.0.116 PriorityQueueAggregate (PRQAGG) . . . 617
6.0.117 QueueAggregate (QUAGG) . . . 622
6.0.118 SetAggregate (SETAGG) . . . 628
6.0.119 StackAggregate (SKAGG) . . . 636
6.0.120 UnaryRecursiveAggregate (URAGG) . . . 642

7 Category Layer 6 **673**
7.0.121 AbelianGroup (ABELGRP) . . . 673
7.0.122 BinaryTreeCategory (BTCAT) . . . 680
7.0.123 Dictionary (DIAGG) . . . 687
7.0.124 DequeueAggregate (DQAGG) . . . 694
7.0.125 ExtensibleLinearAggregate (ELAGG) . . . 700
7.0.126 FiniteLinearAggregate (FLAGG) . . . 709
7.0.127 FreeAbelianMonoidCategory (FAMONC) . . . 719
7.0.128 MultiDictionary (MDAGG) . . . 724
7.0.129 OrderedAbelianMonoid (OAMON) . . . 730
7.0.130 PermutationCategory (PERMCAT) . . . 734
7.0.131 StreamAggregate (STAGG) . . . 739
7.0.132 TriangularSetCategory (TSETCAT) . . . 750

8 Category Layer 7 **775**
8.0.133 FiniteDivisorCategory (FDIVCAT) . . . 776
8.0.134 FiniteSetAggregate (FSAGG) . . . 781
8.0.135 KeyedDictionary (KDAGG) . . . 792
8.0.136 LazyStreamAggregate (LZSTAGG) . . . 799
8.0.137 LeftModule (LMODULE) . . . 823
8.0.138 ListAggregate (LSAGG) . . . 827
8.0.139 MultisetAggregate (MSETAGG) . . . 843
8.0.140 NonAssociativeRng (NARNG) . . . 849
8.0.141 OneDimensionalArrayAggregate (A1AGG) . . . 854
8.0.142 OrderedCancellationAbelianMonoid (OCAMON) . . . 870
8.0.143 RegularTriangularSetCategory (RSETCAT) . . . 873
8.0.144 RightModule (RMODULE) . . . 892
8.0.145 Rng (RNG) . . . 896

9 Category Layer 8 **901**
9.0.146 BiModule (BMODULE) . . . 902
9.0.147 BitAggregate (BTAGG) . . . 907
9.0.148 NonAssociativeRing (NASRING) . . . 917
9.0.149 NormalizedTriangularSetCategory (NTSCAT) . . . 922
9.0.150 OrderedAbelianGroup (OAGROUP) . . . 932
9.0.151 OrderedAbelianMonoidSup (OAMONS) . . . 935
9.0.152 OrderedMultisetAggregate (OMSAGG) . . . 939
9.0.153 Ring (RING) . . . 946
9.0.154 SquareFreeRegularTriangularSetCategory (SFRTCAT) . . . 952
9.0.155 StringAggregate (SRAGG) . . . 961
9.0.156 TableAggregate (TBAGG) . . . 972
9.0.157 VectorCategory (VECTCAT) . . . 985

10 Category Layer 9 **997**
10.0.158 AssociationListAggregate (ALAGG) . . . 997
10.0.159 CharacteristicNonZero (CHARNZ) . . . 1010
10.0.160 CharacteristicZero (CHARZ) . . . 1015
10.0.161 CommutativeRing (COMRING) . . . 1019
10.0.162 DifferentialRing (DIFRING) . . . 1024
10.0.163 EntireRing (ENTIRER) . . . 1029
10.0.164 FreeModuleCat (FMCAT) . . . 1034
10.0.165 LeftAlgebra (LALG) . . . 1040
10.0.166 LinearlyExplicitRingOver (LINEXP) . . . 1045
10.0.167 Module (MODULE) . . . 1050
10.0.168 OrderedRing (ORDRING) . . . 1055
10.0.169 PartialDifferentialRing (PDRING) . . . 1061
10.0.170 PointCategory (PTCAT) . . . 1068
10.0.171 RectangularMatrixCategory (RMATCAT) . . . 1075
10.0.172 SquareFreeNormalizedTriangularSetCategory (SNTSCAT) . . . 1085
10.0.173 StringCategory (STRICAT) . . . 1093
10.0.174 UnivariateSkewPolynomialCategory (OREPCAT) . . . 1101
10.0.175 XAlgebra (XALG) . . . 1116

11 Category Layer 10 **1121**
11.0.176 Algebra (ALGEBRA) . . . 1121
11.0.177 DifferentialExtension (DIFEXT) . . . 1127
11.0.178 FullyLinearlyExplicitRingOver (FLINEXP) . . . 1134
11.0.179 LieAlgebra (LIECAT) . . . 1140
11.0.180 LinearOrdinaryDifferentialOperatorCategory (LODOCAT) . . . 1145
11.0.181 NonAssociativeAlgebra (NAALG) . . . 1154
11.0.182 VectorSpace (VSPACE) . . . 1160
11.0.183 XFreeAlgebra (XFALG) . . . 1164

12 Category Layer 11 **1173**
12.0.184 DirectProductCategory (DIRPCAT) . . . 1173
12.0.185 DivisionRing (DIVRING) . . . 1185
12.0.186 FiniteRankNonAssociativeAlgebra (FINAALG) . . . 1191
12.0.187 FreeLieAlgebra (FLALG) . . . 1219
12.0.188 IntegralDomain (INTDOM) . . . 1225
12.0.189 MonogenicLinearOperator (MLO) . . . 1232
12.0.190 OctonionCategory (OC) . . . 1238
12.0.191 QuaternionCategory (QUATCAT) . . . 1252
12.0.192 SquareMatrixCategory (SMATCAT) . . . 1266
12.0.193 XPolynomialsCat (XPOLYC) . . . 1279

13 Category Layer 12 **1287**
13.0.194 AbelianMonoidRing (AMR) . . . 1287
13.0.195 FortranMachineTypeCategory (FMTC) . . . 1295
13.0.196 FramedNonAssociativeAlgebra (FRNAALG) . . . 1300
13.0.197 GcdDomain (GCDDOM) . . . 1319
13.0.198 OrderedIntegralDomain (OINTDOM) . . . 1326

14 Category Layer 13 **1331**
14.0.199 FiniteAbelianMonoidRing (FAMR) . . . 1331
14.0.200 IntervalCategory (INTCAT) . . . 1341
14.0.201 PowerSeriesCategory (PSCAT) . . . 1349
14.0.202 PrincipalIdealDomain (PID) . . . 1357
14.0.203 UniqueFactorizationDomain (UFD) . . . 1362

15 Category Layer 14 **1369**
15.0.204 DivisorCategory (DIVCAT) . . . 1369
15.0.205 EuclideanDomain (EUCDOM) . . . 1374
15.0.206 MultivariateTaylorSeriesCategory (MTSCAT) . . . 1384
15.0.207 PolynomialFactorizationExplicit (PFECAT) . . . 1393
15.0.208 UnivariatePowerSeriesCategory (UPSCAT) . . . 1401

16 Category Layer 15 **1413**
16.0.209 Field (FIELD) . . . 1413
16.0.210 IntegerNumberSystem (INS) . . . 1420
16.0.211 LocalPowerSeriesCategory (LOCPOWC) . . . 1434
16.0.212 PAdicIntegerCategory (PADICCT) . . . 1443
16.0.213 PolynomialCategory (POLYCAT) . . . 1449
16.0.214 UnivariateTaylorSeriesCategory (UTSCAT) . . . 1476

17 Category Layer 16 **1497**
17.0.215 AlgebraicallyClosedField (ACF) . . . 1497
17.0.216 DifferentialPolynomialCategory (DPOLCAT) . . . 1512
17.0.217 FieldOfPrimeCharacteristic (FPC) . . . 1531
17.0.218 FiniteRankAlgebra (FINRALG) . . . 1537
17.0.219 FunctionSpace (FS) . . . 1544
17.0.220 InfinitlyClosePointCategory (INFCLCT) . . . 1583
17.0.221 PseudoAlgebraicClosureOfPerfectFieldCategory (PACPERC) . . . 1588
17.0.222 QuotientFieldCategory (QFCAT) . . . 1595
17.0.223 RealClosedField (RCFIELD) . . . 1611
17.0.224 RealNumberSystem (RNS) . . . 1622
17.0.225 RecursivePolynomialCategory (RPOLCAT) . . . 1630
17.0.226 UnivariateLaurentSeriesCategory (ULSCAT) . . . 1686
17.0.227 UnivariatePuiseuxSeriesCategory (UPXSCAT) . . . 1697
17.0.228 UnivariatePolynomialCategory (UPOLYC) . . . 1708

18 Category Layer 17 **1739**
18.0.229 AlgebraicallyClosedFunctionSpace (ACFS) . . . 1739
18.0.230 ExtensionField (XF) . . . 1754
18.0.231 FiniteFieldCategory (FFIELDC) . . . 1762
18.0.232 FloatingPointSystem (FPS) . . . 1777
18.0.233 FramedAlgebra (FRAMALG) . . . 1786
18.0.234 PseudoAlgebraicClosureOfFiniteFieldCategory (PACFFC) . . . 1793
18.0.235 UnivariateLaurentSeriesConstructorCategory (ULSCCAT) . . . 1801
18.0.236 UnivariatePuiseuxSeriesConstructorCategory (UPXSCCA) . . . 1817

19 Category Layer 18 **1829**
19.0.237 FiniteAlgebraicExtensionField (FAXF) . . . 1829
19.0.238 MonogenicAlgebra (MONOGEN) . . . 1847
19.0.239 PseudoAlgebraicClosureOfRationalNumberCategory (PACRATC) . . . 1860

20 Category Layer 19 **1869**
20.0.240 ComplexCategory (COMPCAT) . . . 1869
20.0.241 FunctionFieldCategory (FFCAT) . . . 1900
20.0.242 PseudoAlgebraicClosureOfAlgExtOfRationalNumberCategory (PACEXTC) 1927

21 The bootstrap code **1937**
21.1 ABELGRP.lsp BOOTSTRAP . . . 1937
21.2 ABELGRP-.lsp BOOTSTRAP . . . 1938
21.3 ABELMON.lsp BOOTSTRAP . . . 1939
21.4 ABELMON-.lsp BOOTSTRAP . . . 1940
21.5 ABELSG.lsp BOOTSTRAP . . . 1942
21.6 ABELSG-.lsp BOOTSTRAP . . . 1943
21.7 ALAGG.lsp BOOTSTRAP . . . 1944
21.8 CABMON.lsp BOOTSTRAP . . . 1945
21.9 CLAGG.lsp BOOTSTRAP . . . 1946
21.10 CLAGG-.lsp BOOTSTRAP . . . 1948
21.11 COMRING.lsp BOOTSTRAP . . . 1952
21.12 DIFRING.lsp BOOTSTRAP . . . 1953
21.13 DIFRING-.lsp BOOTSTRAP . . . 1954
21.14 DIVRING.lsp BOOTSTRAP . . . 1955
21.15 DIVRING-.lsp BOOTSTRAP . . . 1956
21.16 ES.lsp BOOTSTRAP . . . 1958
21.17 ES-.lsp BOOTSTRAP . . . 1960
21.18 EUCDOM.lsp BOOTSTRAP . . . 1974
21.18.1 The Lisp Implementation . . . 1975
21.19 EUCDOM-.lsp BOOTSTRAP . . . 1977
21.19.1 The Lisp Implementation . . . 1977
21.20 ENTIRER.lsp BOOTSTRAP . . . 1988
21.21 FFIELDC.lsp BOOTSTRAP . . . 1989
21.22 FFIELDC-.lsp BOOTSTRAP . . . 1990
21.23 FPS.lsp BOOTSTRAP . . . 2001

21.24FPS-.lsp BOOTSTRAP 2002
21.25GCDDOM.lsp BOOTSTRAP 2004
21.26GCDDOM-.lsp BOOTSTRAP 2005
21.27HOAGG.lsp BOOTSTRAP 2009
21.28HOAGG-.lsp BOOTSTRAP 2011
21.29INS.lsp BOOTSTRAP 2016
21.30INS-.lsp BOOTSTRAP 2018
21.31INTDOM.lsp BOOTSTRAP 2025
21.32INTDOM-.lsp BOOTSTRAP 2026
21.33LNAGG.lsp BOOTSTRAP 2028
21.34LNAGG-.lsp BOOTSTRAP 2030
21.35LSAGG.lsp BOOTSTRAP 2032
21.36LSAGG-.lsp BOOTSTRAP 2033
21.37MONOID.lsp BOOTSTRAP 2049
21.38MONOID-.lsp BOOTSTRAP 2050
21.39MTSCAT.lsp BOOTSTRAP 2051
21.40OINTDOM.lsp BOOTSTRAP 2053
21.41ORDRING.lsp BOOTSTRAP 2054
21.42ORDRING-.lsp BOOTSTRAP 2055
21.43POLYCAT.lsp BOOTSTRAP 2056
21.44POLYCAT-.lsp BOOTSTRAP 2059
21.45PSETCAT.lsp BOOTSTRAP 2087
21.46PSETCAT-.lsp BOOTSTRAP 2089
21.47QFCAT.lsp BOOTSTRAP 2105
21.48QFCAT-.lsp BOOTSTRAP 2107
21.49RCAGG.lsp BOOTSTRAP 2114
21.50RCAGG-.lsp BOOTSTRAP 2116
21.51RING.lsp BOOTSTRAP 2117
21.52RING-.lsp BOOTSTRAP 2118
21.53RNG.lsp BOOTSTRAP 2119
21.54RNS.lsp BOOTSTRAP 2120
21.55RNS-.lsp BOOTSTRAP 2121
21.56SETAGG.lsp BOOTSTRAP 2125
21.57SETAGG-.lsp BOOTSTRAP 2126
21.58SETCAT.lsp BOOTSTRAP 2127
21.59SETCAT-.lsp BOOTSTRAP 2128
21.60STAGG.lsp BOOTSTRAP 2130
21.61STAGG-.lsp BOOTSTRAP 2131
21.62TSETCAT.lsp BOOTSTRAP 2137
21.63TSETCAT-.lsp BOOTSTRAP 2140
21.64UFD.lsp BOOTSTRAP 2158
21.65UFD-.lsp BOOTSTRAP 2159
21.66ULSCAT.lsp BOOTSTRAP 2161
21.67UPOLYC.lsp BOOTSTRAP 2163
21.68UPOLYC-.lsp BOOTSTRAP 2165
21.69URAGG.lsp BOOTSTRAP 2186

21.70URAGG-.lsp BOOTSTRAP 2188

22 The Proofs **2201**

23 Chunk collections **2205**

Bibliography **2221**

Index **2233**

Volume 10.3: Axiom Algebra: Domains

1 Chapter Overview 1

2 Chapter A 3
domain AFFPL AffinePlane . . . 3
AffinePlane (AFFPL) . . . 4
domain AFFPLPS AffinePlaneOverPseudoAlgebraicClosureOfFiniteField . . . 5
AffinePlaneOverPseudoAlgebraicClosureOfFiniteField (AFFPLPS) . . . 6
domain AFFSP AffineSpace . . . 7
AffineSpace (AFFSP) . . . 9
domain ALGSC AlgebraGivenByStructuralConstants . . . 13
Some examples of algebras in genetics . . . 14
Commutative, non-associative algebras . . . 14
AlgebraGivenByStructuralConstants (ALGSC) . . . 47
domain ALGFF AlgebraicFunctionField . . . 63
AlgebraicFunctionField (ALGFF) . . . 68
domain AN AlgebraicNumber . . . 76
AlgebraicNumber (AN) . . . 87
domain ANON AnonymousFunction . . . 89
AnonymousFunction (ANON) . . . 90
domain ANTISYM AntiSymm . . . 91
AntiSymm (ANTISYM) . . . 103
domain ANY Any . . . 110
Any (ANY) . . . 115
domain ASTACK ArrayStack . . . 118
ArrayStack (ASTACK) . . . 139
domain ASP1 Asp1 . . . 146
Asp1 (ASP1) . . . 147
domain ASP10 Asp10 . . . 152
Asp10 (ASP10) . . . 153
domain ASP12 Asp12 . . . 159
Asp12 (ASP12) . . . 160
domain ASP19 Asp19 . . . 163
Asp19 (ASP19) . . . 166
domain ASP20 Asp20 . . . 174
Asp20 (ASP20) . . . 176
domain ASP24 Asp24 . . . 182
Asp24 (ASP24) . . . 184
domain ASP27 Asp27 . . . 188
Asp27 (ASP27) . . . 190
domain ASP28 Asp28 . . . 194
Asp28 (ASP28) . . . 197
domain ASP29 Asp29 . . . 203
Asp29 (ASP29) . . . 204

domain ASP30 Asp30 . . . 207
Asp30 (ASP30) . . . 209
domain ASP31 Asp31 . . . 213
Asp31 (ASP31) . . . 215
domain ASP33 Asp33 . . . 221
Asp33 (ASP33) . . . 222
domain ASP34 Asp34 . . . 224
Asp34 (ASP34) . . . 226
domain ASP35 Asp35 . . . 230
Asp35 (ASP35) . . . 231
domain ASP4 Asp4 . . . 238
Asp4 (ASP4) . . . 239
domain ASP41 Asp41 . . . 244
Asp41 (ASP41) . . . 246
domain ASP42 Asp42 . . . 254
Asp42 (ASP42) . . . 256
domain ASP49 Asp49 . . . 265
Asp49 (ASP49) . . . 267
domain ASP50 Asp50 . . . 273
Asp50 (ASP50) . . . 275
domain ASP55 Asp55 . . . 281
Asp55 (ASP55) . . . 283
domain ASP6 Asp6 . . . 291
Asp6 (ASP6) . . . 292
domain ASP7 Asp7 . . . 298
Asp7 (ASP7) . . . 299
domain ASP73 Asp73 . . . 304
Asp73 (ASP73) . . . 306
domain ASP74 Asp74 . . . 312
Asp74 (ASP74) . . . 313
domain ASP77 Asp77 . . . 320
Asp77 (ASP77) . . . 322
domain ASP78 Asp78 . . . 327
Asp78 (ASP78) . . . 329
domain ASP8 Asp8 . . . 334
Asp8 (ASP8) . . . 335
domain ASP80 Asp80 . . . 340
Asp80 (ASP80) . . . 341
domain ASP9 Asp9 . . . 347
Asp9 (ASP9) . . . 348
domain JORDAN AssociatedJordanAlgebra . . . 353
AssociatedJordanAlgebra (JORDAN) . . . 356
domain LIE AssociatedLieAlgebra . . . 359
AssociatedLieAlgebra (LIE) . . . 362
domain ALIST AssociationList . . . 365
AssociationList (ALIST) . . . 373

domain ATTRBUT AttributeButtons . . . 377
AttributeButtons (ATTRBUT) . . . 379
domain AUTOMOR Automorphism . . . 386
Automorphism (AUTOMOR) . . . 387

3 Chapter B 391
domain BBTREE BalancedBinaryTree . . . 391
BalancedBinaryTree (BBTREE) . . . 396
domain BPADIC BalancedPAdicInteger . . . 401
BalancedPAdicInteger (BPADIC) . . . 403
domain BPADICRT BalancedPAdicRational . . . 404
BalancedPAdicRational (BPADICRT) . . . 407
domain BFUNCT BasicFunctions . . . 409
BasicFunctions (BFUNCT) . . . 410
domain BOP BasicOperator . . . 413
BasicOperator (BOP) . . . 419
domain BSD BasicStochasticDifferential . . . 427
BasicStochasticDifferential (BSD) . . . 434
domain BINARY BinaryExpansion . . . 437
BinaryExpansion (BINARY) . . . 443
domain BINFILE BinaryFile . . . 445
BinaryFile (BINFILE) . . . 446
domain BSTREE BinarySearchTree . . . 450
BinarySearchTree (BSTREE) . . . 455
domain BTOURN BinaryTournament . . . 458
BinaryTournament (BTOURN) . . . 460
domain BTREE BinaryTree . . . 462
BinaryTree (BTREE) . . . 464
domain BITS Bits . . . 467
Bits (BITS) . . . 469
domain BLHN BlowUpWithHamburgerNoether . . . 471
BlowUpWithHamburgerNoether (BLHN) . . . 472
domain BLQT BlowUpWithQuadTrans . . . 474
BlowUpWithQuadTrans (BLQT) . . . 475
domain BOOLEAN Boolean . . . 477
Boolean (BOOLEAN) . . . 478

4 Chapter C 483
domain CARD CardinalNumber . . . 483
CardinalNumber (CARD) . . . 490
domain CARTEN CartesianTensor . . . 496
CartesianTensor (CARTEN) . . . 515
domain CELL Cell . . . 535
Cell (CELL) . . . 536
domain CHAR Character . . . 539
Character (CHAR) . . . 543

domain CCLASS CharacterClass . . . 549
CharacterClass (CCLASS) . . . 555
domain CLIF CliffordAlgebra . . . 560
Vector (linear) spaces . . . 560
Quadratic Forms . . . 561
Quadratic spaces, Clifford Maps . . . 562
Universal Clifford algebras . . . 562
Real Clifford algebras $\mathbb{R}_{p,q}$ . . . 562
Notation for integer sets . . . 562
Frames for Clifford algebras . . . 563
Real frame groups . . . 563
Canonical products . . . 563
Clifford algebra of frame group . . . 563
Neutral matrix representations . . . 564
Why So Many Product Types? . . . 564
instantiate an instance of CliffordAlgebra . . . 565
CliffordAlgebra (CLIF) . . . 577
domain COLOR Color . . . 585
Color (COLOR) . . . 586
domain COMM Commutator . . . 590
Commutator (COMM) . . . 591
domain COMPLEX Complex . . . 593
Complex (COMPLEX) . . . 602
domain CDFMAT ComplexDoubleFloatMatrix . . . 607
ComplexDoubleFloatMatrix (CDFMAT) . . . 611
domain CDFVEC ComplexDoubleFloatVector . . . 614
ComplexDoubleFloatVector (CDFVEC) . . . 618
domain CONTFRAC ContinuedFraction . . . 621
ContinuedFraction (CONTFRAC) . . . 633

5 Chapter D **647**
domain DBASE Database . . . 647
Database (DBASE) . . . 648
domain DLIST DataList . . . 651
DataList (DLIST) . . . 654
domain DECIMAL DecimalExpansion . . . 656
DecimalExpansion (DECIMAL) . . . 662
domain DHMATRIX DenavitHartenbergMatrix . . . 664
Homogeneous Transformations . . . 664
Notation . . . 664
Vectors . . . 665
Planes . . . 666
Transformations . . . 668
Translation Transformation . . . 668
Rotation Transformations . . . 670
Coordinate Frames . . . 673

Relative Transformations . . . 673
Objects . . . 674
Inverse Transformations . . . 675
General Rotation Transformation . . . 676
Equivalent Angle and Axis of Rotation . . . 678
Example 1.1 . . . 681
Stretching and Scaling . . . 682
Perspective Transformations . . . 683
Transform Equations . . . 685
Summary . . . 685
DenavitHartenbergMatrix (DHMATRIX) . . . 701
domain DEQUEUE Dequeue . . . 704
Dequeue (DEQUEUE) . . . 721
domain DERHAM DeRhamComplex . . . 729
DeRhamComplex (DERHAM) . . . 789
domain DSTREE DesingTree . . . 800
DesingTree (DSTREE) . . . 801
domain DSMP DifferentialSparseMultivariatePolynomial . . . 805
DifferentialSparseMultivariatePolynomial (DSMP) . . . 808
domain DIRPROD DirectProduct . . . 811
DirectProduct (DIRPROD) . . . 813
domain DPMM DirectProductMatrixModule . . . 818
DirectProductMatrixModule (DPMM) . . . 821
domain DPMO DirectProductModule . . . 822
DirectProductModule (DPMO) . . . 825
domain DIRRING DirichletRing . . . 827
DirichletRing (DIRRING) . . . 832
domain DMP DistributedMultivariatePolynomial . . . 837
DistributedMultivariatePolynomial (DMP) . . . 844
domain DIV Divisor . . . 845
Divisor (DIV) . . . 847
domain DFLOAT DoubleFloat . . . 853
DoubleFloat (DFLOAT) . . . 862
domain DFMAT DoubleFloatMatrix . . . 879
DoubleFloatMatrix (DFMAT) . . . 882
domain DFVEC DoubleFloatVector . . . 885
DoubleFloatVector (DFVEC) . . . 889
domain DROPT DrawOption . . . 892
DrawOption (DROPT) . . . 893
domain D01AJFA d01ajfAnnaType . . . 901
d01ajfAnnaType (D01AJFA) . . . 902
domain D01AKFA d01akfAnnaType . . . 905
d01akfAnnaType (D01AKFA) . . . 906
domain D01ALFA d01alfAnnaType . . . 909
d01alfAnnaType (D01ALFA) . . . 910
domain D01AMFA d01amfAnnaType . . . 913

d01amfAnnaType (D01AMFA) . . . 914
domain D01ANFA d01anfAnnaType . . . 917
d01anfAnnaType (D01ANFA) . . . 919
domain D01APFA d01apfAnnaType . . . 922
d01apfAnnaType (D01APFA) . . . 923
domain D01AQFA d01aqfAnnaType . . . 927
d01aqfAnnaType (D01AQFA) . . . 928
domain D01ASFA d01asfAnnaType . . . 931
d01asfAnnaType (D01ASFA) . . . 932
domain D01FCFA d01fcfAnnaType . . . 936
d01fcfAnnaType (D01FCFA) . . . 937
domain D01GBFA d01gbfAnnaType . . . 940
d01gbfAnnaType (D01GBFA) . . . 941
domain D01TRNS d01TransformFunctionType . . . 944
d01TransformFunctionType (D01TRNS) . . . 945
domain D02BBFA d02bbfAnnaType . . . 951
d02bbfAnnaType (D02BBFA) . . . 952
domain D02BHFA d02bhfAnnaType . . . 956
d02bhfAnnaType (D02BHFA) . . . 958
domain D02CJFA d02cjfAnnaType . . . 962
d02cjfAnnaType (D02CJFA) . . . 963
domain D02EJFA d02ejfAnnaType . . . 966
d02ejfAnnaType (D02EJFA) . . . 967
domain D03EEFA d03eefAnnaType . . . 972
d03eefAnnaType (D03EEFA) . . . 973
domain D03FAFA d03fafAnnaType . . . 977
d03fafAnnaType (D03FAFA) . . . 978

6 Chapter E 981
domain EFULS ElementaryFunctionsUnivariateLaurentSeries . . . 981
ElementaryFunctionsUnivariateLaurentSeries (EFULS) . . . 983
domain EFUPXS ElementaryFunctionsUnivariatePuiseuxSeries . . . 997
ElementaryFunctionsUnivariatePuiseuxSeries (EFUPXS) . . . 999
domain EQ Equation . . . 1010
Equation (EQ) . . . 1016
domain EQTBL EqTable . . . 1026
EqTable (EQTBL) . . . 1030
domain EMR EuclideanModularRing . . . 1031
EuclideanModularRing (EMR) . . . 1033
domain EXIT Exit . . . 1037
Exit (EXIT) . . . 1040
domain EXPEXPAN ExponentialExpansion . . . 1041
ExponentialExpansion (EXPEXPAN) . . . 1044
domain EXPR Expression . . . 1050
Expression (EXPR) . . . 1062
domain EXPUPXS ExponentialOfUnivariatePuiseuxSeries . . . 1089

ExponentialOfUnivariatePuiseuxSeries (EXPUPXS) . . . 1093
domain EAB ExtAlgBasis . . . 1096
ExtAlgBasis (EAB) . . . 1097
domain E04DGFA e04dgfAnnaType . . . 1100
e04dgfAnnaType (E04DGFA) . . . 1101
domain E04FDFA e04fdfAnnaType . . . 1104
e04fdfAnnaType (E04FDFA) . . . 1105
domain E04GCFA e04gcfAnnaType . . . 1110
e04gcfAnnaType (E04GCFA) . . . 1111
domain E04JAFA e04jafAnnaType . . . 1116
e04jafAnnaType (E04JAFA) . . . 1117
domain E04MBFA e04mbfAnnaType . . . 1121
e04mbfAnnaType (E04MBFA) . . . 1122
domain E04NAFA e04nafAnnaType . . . 1126
e04nafAnnaType (E04NAFA) . . . 1127
domain E04UCFA e04ucfAnnaType . . . 1131
e04ucfAnnaType (E04UCFA) . . . 1132

7 Chapter F 1137
domain FR Factored . . . 1137
Factored (FR) . . . 1150
domain FILE File . . . 1169
File (FILE) . . . 1174
domain FNAME FileName . . . 1178
FileName (FNAME) . . . 1184
domain FDIV FiniteDivisor . . . 1186
FiniteDivisor (FDIV) . . . 1187
domain FF FiniteField . . . 1192
FiniteField (FF) . . . 1195
domain FFCG FiniteFieldCyclicGroup . . . 1197
FiniteFieldCyclicGroup (FFCG) . . . 1200
domain FFCGX FiniteFieldCyclicGroupExtension . . . 1202
FiniteFieldCyclicGroupExtension (FFCGX) . . . 1205
domain FFCGP FiniteFieldCyclicGroupExtensionByPolynomial . . . 1207
FiniteFieldCyclicGroupExtensionByPolynomial (FFCGP) . . . 1210
domain FFX FiniteFieldExtension . . . 1222
FiniteFieldExtension (FFX) . . . 1225
domain FFP FiniteFieldExtensionByPolynomial . . . 1227
FiniteFieldExtensionByPolynomial (FFP) . . . 1230
domain FFNB FiniteFieldNormalBasis . . . 1240
FiniteFieldNormalBasis (FFNB) . . . 1242
domain FFNBX FiniteFieldNormalBasisExtension . . . 1244
FiniteFieldNormalBasisExtension (FFNBX) . . . 1247
domain FFNBP FiniteFieldNormalBasisExtensionByPolynomial . . . 1249
FiniteFieldNormalBasisExtensionByPolynomial (FFNBP) . . . 1252
domain FARRAY FlexibleArray . . . 1267

FlexibleArray (FARRAY) . . . 1274
domain FLOAT Float . . . 1275
Float (FLOAT) . . . 1297
domain FC FortranCode . . . 1337
FortranCode (FC) . . . 1339
domain FEXPR FortranExpression . . . 1360
FortranExpression (FEXPR) . . . 1363
domain FORTRAN FortranProgram . . . 1374
FortranProgram (FORTRAN) . . . 1376
domain FST FortranScalarType . . . 1384
FortranScalarType (FST) . . . 1385
domain FTEM FortranTemplate . . . 1391
FortranTemplate (FTEM) . . . 1392
domain FT FortranType . . . 1396
FortranType (FT) . . . 1397
domain FCOMP FourierComponent . . . 1401
FourierComponent (FCOMP) . . . 1402
domain FSERIES FourierSeries . . . 1404
FourierSeries (FSERIES) . . . 1406
domain FRAC Fraction . . . 1409
Fraction (FRAC) . . . 1416
domain FRIDEAL FractionalIdeal . . . 1430
FractionalIdeal (FRIDEAL) . . . 1432
domain FRMOD FramedModule . . . 1439
FramedModule (FRMOD) . . . 1440
domain FAGROUP FreeAbelianGroup . . . 1444
FreeAbelianGroup (FAGROUP) . . . 1449
domain FAMONOID FreeAbelianMonoid . . . 1451
FreeAbelianMonoid (FAMONOID) . . . 1452
domain FGROUP FreeGroup . . . 1453
FreeGroup (FGROUP) . . . 1455
domain FM FreeModule . . . 1458
FreeModule (FM) . . . 1459
domain FM1 FreeModule1 . . . 1462
FreeModule1 (FM1) . . . 1464
domain FMONOID FreeMonoid . . . 1468
FreeMonoid (FMONOID) . . . 1470
domain FNLA FreeNilpotentLie . . . 1477
FreeNilpotentLie (FNLA) . . . 1479
domain FPARFRAC FullPartialFractionExpansion . . . 1483
FullPartialFractionExpansion (FPARFRAC) . . . 1493
domain FUNCTION FunctionCalled . . . 1500
FunctionCalled (FUNCTION) . . . 1501

8 Chapter G **1503**
domain GDMP GeneralDistributedMultivariatePolynomial 1503
GeneralDistributedMultivariatePolynomial (GDMP) 1513
domain GMODPOL GeneralModulePolynomial 1523
GeneralModulePolynomial (GMODPOL) 1524
domain GCNAALG GenericNonAssociativeAlgebra 1527
GenericNonAssociativeAlgebra (GCNAALG) 1530
domain GPOLSET GeneralPolynomialSet 1540
GeneralPolynomialSet (GPOLSET) 1542
domain GSTBL GeneralSparseTable 1546
GeneralSparseTable (GSTBL) 1549
domain GTSET GeneralTriangularSet 1551
GeneralTriangularSet (GTSET) 1554
domain GSERIES GeneralUnivariatePowerSeries 1560
GeneralUnivariatePowerSeries (GSERIES) 1563
domain GRIMAGE GraphImage 1568
GraphImage (GRIMAGE) 1569
domain GOPT GuessOption 1583
GuessOption (GOPT) 1585
domain GOPT0 GuessOptionFunctions0 1591
GuessOptionFunctions0 (GOPT0) 1592

9 Chapter H **1603**
domain HASHTBL HashTable 1603
HashTable (HASHTBL) 1605
domain HEAP Heap 1608
Heap (HEAP) 1619
domain HEXADEC HexadecimalExpansion 1626
HexadecimalExpansion (HEXADEC) 1631
package HTMLFORM HTMLFormat 1635
Overview 1635
Why output to HTML? 1635
Using the formatter 1636
Form of the output 1636
Matrix Formatting 1636
Programmers Guide 1637
Future Developments 1637
HTMLFormat (HTMLFORM) 1641
domain HDP HomogeneousDirectProduct 1673
HomogeneousDirectProduct (HDP) 1676
domain HDMP HomogeneousDistributedMultivariatePolynomial 1678
HomogeneousDistributedMultivariatePolynomial (HDMP) 1684
domain HELLFDIV HyperellipticFiniteDivisor 1686
HyperellipticFiniteDivisor (HELLFDIV) 1688

10 Chapter I **1695**
domain ICP InfClsPt . . . 1695
InfClsPt (ICP) . . . 1696
domain ICARD IndexCard . . . 1698
IndexCard (ICARD) . . . 1699
domain IBITS IndexedBits . . . 1702
IndexedBits (IBITS) . . . 1707
domain IDPAG IndexedDirectProductAbelianGroup . . . 1710
IndexedDirectProductAbelianGroup (IDPAG) . . . 1712
domain IDPAM IndexedDirectProductAbelianMonoid . . . 1715
IndexedDirectProductAbelianMonoid (IDPAM) . . . 1716
domain IDPO IndexedDirectProductObject . . . 1720
IndexedDirectProductObject (IDPO) . . . 1721
domain IDPOAM IndexedDirectProductOrderedAbelianMonoid . . . 1723
IndexedDirectProductOrderedAbelianMonoid (IDPOAM) . . . 1725
domain IDPOAMS IndexedDirectProductOrderedAbelianMonoidSup . . . 1726
IndexedDirectProductOrderedAbelianMonoidSup (IDPOAMS) . . . 1728
domain INDE IndexedExponents . . . 1730
IndexedExponents (INDE) . . . 1731
domain IFARRAY IndexedFlexibleArray . . . 1733
IndexedFlexibleArray (IFARRAY) . . . 1736
domain ILIST IndexedList . . . 1745
IndexedList (ILIST) . . . 1748
domain IMATRIX IndexedMatrix . . . 1757
IndexedMatrix (IMATRIX) . . . 1759
domain IARRAY1 IndexedOneDimensionalArray . . . 1762
IndexedOneDimensionalArray (IARRAY1) . . . 1765
domain ISTRING IndexedString . . . 1769
IndexedString (ISTRING) . . . 1772
domain IARRAY2 IndexedTwoDimensionalArray . . . 1781
IndexedTwoDimensionalArray (IARRAY2) . . . 1783
domain IVECTOR IndexedVector . . . 1784
IndexedVector (IVECTOR) . . . 1787
domain ITUPLE InfiniteTuple . . . 1788
InfiniteTuple (ITUPLE) . . . 1789
domain INFCLSPT InfinitlyClosePoint . . . 1791
InfinitlyClosePoint (INFCLSPT) . . . 1792
domain INFCLSPS InfinitlyClosePointOverPseudoAlgebraicClosureOfFiniteField . 1799
InfinitlyClosePointOverPseudoAlgebraicClosureOfFiniteField (INFCLSPS) . . 1800
domain IAN InnerAlgebraicNumber . . . 1802
InnerAlgebraicNumber (IAN) . . . 1804
domain IFF InnerFiniteField . . . 1811
InnerFiniteField (IFF) . . . 1813
domain IFAMON InnerFreeAbelianMonoid . . . 1815
InnerFreeAbelianMonoid (IFAMON) . . . 1816
domain IIARRAY2 InnerIndexedTwoDimensionalArray . . . 1819

InnerIndexedTwoDimensionalArray (IIARRAY2) . . . 1821
domain IPADIC InnerPAdicInteger . . . 1825
InnerPAdicInteger (IPADIC) . . . 1826
domain IPF InnerPrimeField . . . 1836
InnerPrimeField (IPF) . . . 1839
domain ISUPS InnerSparseUnivariatePowerSeries . . . 1847
InnerSparseUnivariatePowerSeries (ISUPS) . . . 1850
domain INTABL InnerTable . . . 1890
InnerTable (INTABL) . . . 1892
domain ITAYLOR InnerTaylorSeries . . . 1894
InnerTaylorSeries (ITAYLOR) . . . 1895
domain INFORM InputForm . . . 1901
InputForm (INFORM) . . . 1902
domain INT Integer . . . 1909
Integer (INT) . . . 1923
domain ZMOD IntegerMod . . . 1935
IntegerMod (ZMOD) . . . 1936
domain INTFTBL IntegrationFunctionsTable . . . 1942
IntegrationFunctionsTable (INTFTBL) . . . 1943
domain IR IntegrationResult . . . 1948
IntegrationResult (IR) . . . 1949
domain INTRVL Interval . . . 1956
Interval (INTRVL) . . . 1961

11 Chapter J **1979**

12 Chapter K **1981**
domain KERNEL Kernel . . . 1981
Kernel (KERNEL) . . . 1987
domain KAFILE KeyedAccessFile . . . 1993
KeyedAccessFile (KAFILE) . . . 2000

13 Chapter L **2007**
domain LAUPOL LaurentPolynomial . . . 2007
LaurentPolynomial (LAUPOL) . . . 2009
domain LIB Library . . . 2017
Library (LIB) . . . 2021
domain LEXP LieExponentials . . . 2023
LieExponentials (LEXP) . . . 2028
domain LPOLY LiePolynomial . . . 2032
LiePolynomial (LPOLY) . . . 2041
domain LSQM LieSquareMatrix . . . 2048
LieSquareMatrix (LSQM) . . . 2052
domain LODO LinearOrdinaryDifferentialOperator . . . 2056
LinearOrdinaryDifferentialOperator (LODO) . . . 2067
domain LODO1 LinearOrdinaryDifferentialOperator1 . . . 2069

LinearOrdinaryDifferentialOperator1 (LODO1) . . . 2078
domain LODO2 LinearOrdinaryDifferentialOperator2 . . . 2079
LinearOrdinaryDifferentialOperator2 (LODO2) . . . 2090
domain LIST List . . . 2092
List (LIST) . . . 2105
domain LMOPS ListMonoidOps . . . 2111
ListMonoidOps (LMOPS) . . . 2112
domain LMDICT ListMultiDictionary . . . 2119
ListMultiDictionary (LMDICT) . . . 2120
domain LA LocalAlgebra . . . 2127
LocalAlgebra (LA) . . . 2128
domain LO Localize . . . 2130
Localize (LO) . . . 2131
domain LWORD LyndonWord . . . 2135
LyndonWord (LWORD) . . . 2142

14 Chapter M **2149**
domain MCMPLX MachineComplex . . . 2149
MachineComplex (MCMPLX) . . . 2153
domain MFLOAT MachineFloat . . . 2156
MachineFloat (MFLOAT) . . . 2158
domain MINT MachineInteger . . . 2170
MachineInteger (MINT) . . . 2173
domain MAGMA Magma . . . 2175
Magma (MAGMA) . . . 2182
domain MKCHSET MakeCachableSet . . . 2187
MakeCachableSet (MKCHSET) . . . 2188
domain MMLFORM MathMLFormat . . . 2190
Introduction to Mathematical Markup Language . . . 2191
Displaying MathML . . . 2192
Test Cases . . . 2192
)set output mathml on . . . 2193
File src/interp/setvars.boot.pamphlet . . . 2193
File setvart.boot.pamphlet . . . 2194
File src/algebra/Makefile.pamphlet . . . 2194
File src/algebra/exposed.lsp.pamphlet . . . 2194
File src/algebra/Lattice.pamphlet . . . 2194
File src/doc/axiom.bib.pamphlet . . . 2195
File interp/i-output.boot.pamphlet . . . 2195
Public Declarations . . . 2195
Private Constant Declarations . . . 2197
Private Function Declarations . . . 2198
Public Function Definitions . . . 2200
Private Function Definitions . . . 2201
Mathematical Markup Language Form . . . 2216
MathMLForm (MMLFORM) . . . 2220

domain MATRIX Matrix . . . 2235
Matrix (MATRIX) . . . 2254
domain MODMON ModMonic . . . 2259
ModMonic (MODMON) . . . 2263
domain MODFIELD ModularField . . . 2272
ModularField (MODFIELD) . . . 2273
domain MODRING ModularRing . . . 2275
ModularRing (MODRING) . . . 2276
domain MODMONOM ModuleMonomial . . . 2280
ModuleMonomial (MODMONOM) . . . 2281
domain MODOP ModuleOperator . . . 2283
ModuleOperator (MODOP) . . . 2285
domain MOEBIUS MoebiusTransform . . . 2294
MoebiusTransform (MOEBIUS) . . . 2295
domain MRING MonoidRing . . . 2300
MonoidRing (MRING) . . . 2301
domain MSET Multiset . . . 2315
Multiset (MSET) . . . 2320
domain MPOLY MultivariatePolynomial . . . 2332
MultivariatePolynomial (MPOLY) . . . 2339
domain MYEXPR MyExpression . . . 2340
MyExpression (MYEXPR) . . . 2344
domain MYUP MyUnivariatePolynomial . . . 2347
MyUnivariatePolynomial (MYUP) . . . 2351

15 Chapter N 2355
domain NSDPS NeitherSparseOrDensePowerSeries . . . 2355
NeitherSparseOrDensePowerSeries (NSDPS) . . . 2359
domain NSMP NewSparseMultivariatePolynomial . . . 2370
NewSparseMultivariatePolynomial (NSMP) . . . 2374
domain NSUP NewSparseUnivariatePolynomial . . . 2391
NewSparseUnivariatePolynomial (NSUP) . . . 2395
domain NONE None . . . 2406
None (NONE) . . . 2408
domain NNI NonNegativeInteger . . . 2409
NonNegativeInteger (NNI) . . . 2411
domain NOTTING NottinghamGroup . . . 2414
NottinghamGroup (NOTTING) . . . 2417
domain NIPROB NumericalIntegrationProblem . . . 2418
NumericalIntegrationProblem (NIPROB) . . . 2420
domain ODEPROB NumericalODEProblem . . . 2422
NumericalODEProblem (ODEPROB) . . . 2424
domain OPTPROB NumericalOptimizationProblem . . . 2426
NumericalOptimizationProblem (OPTPROB) . . . 2427
domain PDEPROB NumericalPDEProblem . . . 2430
NumericalPDEProblem (PDEPROB) . . . 2431

16 Chapter O **2435**
domain OCT Octonion . . . 2435
Octonion (OCT) . . . 2442
domain ODEIFTBL ODEIntensityFunctionsTable . . . 2445
ODEIntensityFunctionsTable (ODEIFTBL) . . . 2446
domain ARRAY1 OneDimensionalArray . . . 2450
OneDimensionalArray (ARRAY1) . . . 2454
domain ONECOMP OnePointCompletion . . . 2456
OnePointCompletion (ONECOMP) . . . 2458
domain OMCONN OpenMathConnection . . . 2463
OpenMathConnection (OMCONN) . . . 2464
domain OMDEV OpenMathDevice . . . 2466
OpenMathDevice (OMDEV) . . . 2467
domain OMENC OpenMathEncoding . . . 2475
OpenMathEncoding (OMENC) . . . 2476
domain OMERR OpenMathError . . . 2478
OpenMathError (OMERR) . . . 2479
domain OMERRK OpenMathErrorKind . . . 2481
OpenMathErrorKind (OMERRK) . . . 2483
domain OP Operator . . . 2485
Operator (OP) . . . 2493
domain OMLO OppositeMonogenicLinearOperator . . . 2494
OppositeMonogenicLinearOperator (OMLO) . . . 2496
domain ORDCOMP OrderedCompletion . . . 2498
OrderedCompletion (ORDCOMP) . . . 2499
domain ODP OrderedDirectProduct . . . 2505
OrderedDirectProduct (ODP) . . . 2511
domain OFMONOID OrderedFreeMonoid . . . 2513
OrderedFreeMonoid (OFMONOID) . . . 2523
domain OVAR OrderedVariableList . . . 2530
OrderedVariableList (OVAR) . . . 2533
domain ODPOL OrderlyDifferentialPolynomial . . . 2535
OrderlyDifferentialPolynomial (ODPOL) . . . 2551
domain ODVAR OrderlyDifferentialVariable . . . 2553
OrderlyDifferentialVariable (ODVAR) . . . 2554
domain ODR OrdinaryDifferentialRing . . . 2556
OrdinaryDifferentialRing (ODR) . . . 2558
domain OWP OrdinaryWeightedPolynomials . . . 2560
OrdinaryWeightedPolynomials (OWP) . . . 2561
domain OSI OrdSetInts . . . 2563
OrdSetInts (OSI) . . . 2564
domain OUTFORM OutputForm . . . 2566
OutputForm (OUTFORM) . . . 2568

17 Chapter P **2589**
domain PADIC PAdicInteger . . . 2589
PAdicInteger (PADIC) . . . 2591
domain PADICRAT PAdicRational . . . 2592
PAdicRational (PADICRAT) . . . 2595
domain PADICRC PAdicRationalConstructor . . . 2597
PAdicRationalConstructor (PADICRC) . . . 2600
domain PALETTE Palette . . . 2607
Palette (PALETTE) . . . 2609
domain PARPCURV ParametricPlaneCurve . . . 2611
ParametricPlaneCurve (PARPCURV) . . . 2612
domain PARSCURV ParametricSpaceCurve . . . 2614
ParametricSpaceCurve (PARSCURV) . . . 2615
domain PARSURF ParametricSurface . . . 2616
ParametricSurface (PARSURF) . . . 2618
domain PFR PartialFraction . . . 2619
PartialFraction (PFR) . . . 2628
domain PRTITION Partition . . . 2641
Partition (PRTITION) . . . 2642
domain PATTERN Pattern . . . 2647
Pattern (PATTERN) . . . 2648
domain PATLRES PatternMatchListResult . . . 2663
PatternMatchListResult (PATLRES) . . . 2665
domain PATRES PatternMatchResult . . . 2667
PatternMatchResult (PATRES) . . . 2668
domain PENDTREE PendantTree . . . 2673
PendantTree (PENDTREE) . . . 2674
domain PERM Permutation . . . 2677
Permutation (PERM) . . . 2681
domain PERMGRP PermutationGroup . . . 2695
Introduction by Martin Baker . . . 2695
History . . . 2695
Scaling Up . . . 2695
PermutationGroup Representation . . . 2696
How to find Stabilizers . . . 2700
Stabilizers as Subgroups . . . 2700
Schreier's Lemma . . . 2703
Vectors . . . 2704
Schreier Vectors (Orbit With SVC) . . . 2705
PermutationGroup Representation . . . 2706
Example 1 - Dihedral Group 3 . . . 2708
Example 2 - Symmetric Group 4 . . . 2709
Example 3 - Semiregular or Free Action (Id is only Stabilizer) . . . 2710
Example 4 - Direct Product . . . 2712
Local function: orbitWithSvc . . . 2713
Local function CosetRep1 . . . 2717

Local function strip1 . . . 2719
Local function bsgs . . . 2720
Local function bsgs1 . . . 2721
PermutationGroup (PERMGRP) . . . 2749
domain HACKPI Pi . . . 2789
Pi (HACKPI) . . . 2791
domain ACPLOT PlaneAlgebraicCurvePlot . . . 2794
PlaneAlgebraicCurvePlot (ACPLOT) . . . 2806
domain PLACES Places . . . 2850
Places (PLACES) . . . 2852
domain PLACESPS PlacesOverPseudoAlgebraicClosureOfFiniteField . . . 2853
PlacesOverPseudoAlgebraicClosureOfFiniteField (PLACESPS) . . . 2854
domain PLCS Plcs . . . 2855
Plcs (PLCS) . . . 2856
domain PLOT Plot . . . 2862
Plot (PLOT) . . . 2865
domain PLOT3D Plot3D . . . 2885
Plot3D (PLOT3D) . . . 2886
domain PBWLB PoincareBirkhoffWittLyndonBasis . . . 2904
PoincareBirkhoffWittLyndonBasis (PBWLB) . . . 2905
domain POINT Point . . . 2909
Point (POINT) . . . 2912
domain POLY Polynomial . . . 2914
Polynomial (POLY) . . . 2931
domain IDEAL PolynomialIdeals . . . 2934
PolynomialIdeals (IDEAL) . . . 2935
domain PR PolynomialRing . . . 2950
PolynomialRing (PR) . . . 2952
domain PI PositiveInteger . . . 2964
PositiveInteger (PI) . . . 2965
domain PF PrimeField . . . 2966
PrimeField (PF) . . . 2970
domain PRIMARR PrimitiveArray . . . 2972
PrimitiveArray (PRIMARR) . . . 2974
domain PRODUCT Product . . . 2977
Product (PRODUCT) . . . 2980
domain PROJPL ProjectivePlane . . . 2984
ProjectivePlane (PROJPL) . . . 2986
domain PROJPLPS ProjectivePlaneOverPseudoAlgebraicClosureOfFiniteField . . . 2987
ProjectivePlaneOverPseudoAlgebraicClosureOfFiniteField (PROJPLPS) . . . 2988
domain PROJSP ProjectiveSpace . . . 2989
ProjectiveSpace (PROJSP) . . . 2990
domain PACEXT PseudoAlgebraicClosureOfAlgExtOfRationalNumber . . . 2996
PseudoAlgebraicClosureOfAlgExtOfRationalNumber (PACEXT) . . . 2998
domain PACOFF PseudoAlgebraicClosureOfFiniteField . . . 3010
PseudoAlgebraicClosureOfFiniteField (PACOFF) . . . 3013

domain PACRAT PseudoAlgebraicClosureOfRationalNumber 3027
PseudoAlgebraicClosureOfRationalNumber (PACRAT) 3029

18 Chapter Q **3043**
domain QFORM QuadraticForm 3043
QuadraticForm (QFORM) 3044
domain QALGSET QuasiAlgebraicSet 3046
QuasiAlgebraicSet (QALGSET) 3047
domain QUAT Quaternion 3054
Quaternion (QUAT) 3060
domain QEQUAT QueryEquation 3062
QueryEquation (QEQUAT) 3063
domain QUEUE Queue 3064
Queue (QUEUE) 3077

19 Chapter R **3085**
domain RADFF RadicalFunctionField 3085
RadicalFunctionField (RADFF) 3089
domain RADIX RadixExpansion 3098
RadixExpansion (RADIX) 3106
domain RECLOS RealClosure 3117
RealClosure (RECLOS) 3142
domain RMATRIX RectangularMatrix 3153
RectangularMatrix (RMATRIX) 3155
domain REF Reference 3159
Reference (REF) 3160
domain RGCHAIN RegularChain 3162
RegularChain (RGCHAIN) 3165
domain REGSET RegularTriangularSet 3168
RegularTriangularSet (REGSET) 3195
domain RESRING ResidueRing 3212
ResidueRing (RESRING) 3213
domain RESULT Result 3216
Result (RESULT) 3218
domain RULE RewriteRule 3221
RewriteRule (RULE) 3223
domain ROIRC RightOpenIntervalRootCharacterization 3229
RightOpenIntervalRootCharacterization (ROIRC) 3230
domain ROMAN RomanNumeral 3247
RomanNumeral (ROMAN) 3254
domain ROUTINE RoutinesTable 3256
RoutinesTable (ROUTINE) 3259
domain RULECOLD RuleCalled 3276
RuleCalled (RULECOLD) 3277
domain RULESET Ruleset 3278
Ruleset (RULESET) 3279

20 Chapter S **3283**
domain FORMULA ScriptFormulaFormat . . . 3283
ScriptFormulaFormat (FORMULA) . . . 3284
domain SEG Segment . . . 3299
Segment (SEG) . . . 3303
domain SEGBIND SegmentBinding . . . 3307
SegmentBinding (SEGBIND) . . . 3310
domain SET Set . . . 3311
Set (SET) . . . 3319
domain SETMN SetOfMIntegersInOneToN . . . 3326
SetOfMIntegersInOneToN (SETMN) . . . 3328
domain SDPOL SequentialDifferentialPolynomial . . . 3334
SequentialDifferentialPolynomial (SDPOL) . . . 3337
domain SDVAR SequentialDifferentialVariable . . . 3339
SequentialDifferentialVariable (SDVAR) . . . 3341
domain SEX SExpression . . . 3343
SExpression (SEX) . . . 3344
domain SEXOF SExpressionOf . . . 3345
SExpressionOf (SEXOF) . . . 3346
domain SAE SimpleAlgebraicExtension . . . 3350
SimpleAlgebraicExtension (SAE) . . . 3353
domain SCELL SimpleCell . . . 3362
SimpleCell (SCELL) . . . 3363
domain SFORT SimpleFortranProgram . . . 3367
SimpleFortranProgram (SFORT) . . . 3368
domain SINT SingleInteger . . . 3371
SingleInteger (SINT) . . . 3376
domain SAOS SingletonAsOrderedSet . . . 3386
SingletonAsOrderedSet (SAOS) . . . 3387
domain SEM SparseEchelonMatrix . . . 3389
SparseEchelonMatrix (SEM) . . . 3390
domain SMP SparseMultivariatePolynomial . . . 3417
SparseMultivariatePolynomial (SMP) . . . 3420
domain SMTS SparseMultivariateTaylorSeries . . . 3443
SparseMultivariateTaylorSeries (SMTS) . . . 3450
domain STBL SparseTable . . . 3465
SparseTable (STBL) . . . 3469
domain SULS SparseUnivariateLaurentSeries . . . 3470
SparseUnivariateLaurentSeries (SULS) . . . 3474
domain SUP SparseUnivariatePolynomial . . . 3484
SparseUnivariatePolynomial (SUP) . . . 3489
domain SUPEXPR SparseUnivariatePolynomialExpressions . . . 3504
SparseUnivariatePolynomialExpressions (SUPEXPR) . . . 3508
domain SUPXS SparseUnivariatePuiseuxSeries . . . 3512
SparseUnivariatePuiseuxSeries (SUPXS) . . . 3515
domain ORESUP SparseUnivariateSkewPolynomial . . . 3519

SparseUnivariateSkewPolynomial (ORESUP) . . . 3521
domain SUTS SparseUnivariateTaylorSeries . . . 3523
SparseUnivariateTaylorSeries (SUTS) . . . 3526
domain SHDP SplitHomogeneousDirectProduct . . . 3543
SplitHomogeneousDirectProduct (SHDP) . . . 3546
domain SPLNODE SplittingNode . . . 3548
SplittingNode (SPLNODE) . . . 3549
domain SPLTREE SplittingTree . . . 3555
SplittingTree (SPLTREE) . . . 3557
domain SREGSET SquareFreeRegularTriangularSet . . . 3569
SquareFreeRegularTriangularSet (SREGSET) . . . 3580
domain SQMATRIX SquareMatrix . . . 3597
SquareMatrix (SQMATRIX) . . . 3602
domain STACK Stack . . . 3608
Stack (STACK) . . . 3619
domain SD StochasticDifferential . . . 3625
StochasticDifferential (SD) . . . 3630
domain STREAM Stream . . . 3638
Stream (STREAM) . . . 3644
domain STRING String . . . 3666
String (STRING) . . . 3678
domain STRTBL StringTable . . . 3681
StringTable (STRTBL) . . . 3684
domain SUBSPACE SubSpace . . . 3685
SubSpace (SUBSPACE) . . . 3687
domain COMPPROP SubSpaceComponentProperty . . . 3703
SubSpaceComponentProperty (COMPPROP) . . . 3704
domain SUCH SuchThat . . . 3706
SuchThat (SUCH) . . . 3707
domain SWITCH Switch . . . 3709
Switch (SWITCH) . . . 3710
domain SYMBOL Symbol . . . 3714
Symbol (SYMBOL) . . . 3722
domain SYMTAB SymbolTable . . . 3736
SymbolTable (SYMTAB) . . . 3737
domain SYMPOLY SymmetricPolynomial . . . 3744
SymmetricPolynomial (SYMPOLY) . . . 3745

21 Chapter T **3749**
domain TABLE Table . . . 3749
Table (TABLE) . . . 3756
domain TABLEAU Tableau . . . 3758
Tableau (TABLEAU) . . . 3759
domain TS TaylorSeries . . . 3761
TaylorSeries (TS) . . . 3764
domain TEX TexFormat . . . 3766

product(product(i*j,i=a..b),j=c..d) fix . . . 3766
TexFormat (TEX) . . . 3770
domain TEXTFILE TextFile . . . 3790
TextFile (TEXTFILE) . . . 3794
domain SYMS TheSymbolTable . . . 3798
TheSymbolTable (SYMS) . . . 3799
domain M3D ThreeDimensionalMatrix . . . 3806
ThreeDimensionalMatrix (M3D) . . . 3808
domain VIEW3D ThreeDimensionalViewport . . . 3817
ThreeDimensionalViewport (VIEW3D) . . . 3819
domain SPACE3 ThreeSpace . . . 3850
ThreeSpace (SPACE3) . . . 3852
domain TREE Tree . . . 3867
Tree (TREE) . . . 3869
domain TUBE TubePlot . . . 3883
TubePlot (TUBE) . . . 3884
domain TUPLE Tuple . . . 3886
Tuple (TUPLE) . . . 3887
domain ARRAY2 TwoDimensionalArray . . . 3889
TwoDimensionalArray (ARRAY2) . . . 3899
domain VIEW2D TwoDimensionalViewport . . . 3900
TwoDimensionalViewport (VIEW2D) . . . 3906

22 Chapter U 3929
domain UFPS UnivariateFormalPowerSeries . . . 3929
UnivariateFormalPowerSeries (UFPS) . . . 3932
domain ULS UnivariateLaurentSeries . . . 3933
UnivariateLaurentSeries (ULS) . . . 3939
domain ULSCONS UnivariateLaurentSeriesConstructor . . . 3942
UnivariateLaurentSeriesConstructor (ULSCONS) . . . 3947
domain UP UnivariatePolynomial . . . 3967
UnivariatePolynomial (UP) . . . 3983
domain UPXS UnivariatePuiseuxSeries . . . 3986
UnivariatePuiseuxSeries (UPXS) . . . 3989
domain UPXSCONS UnivariatePuiseuxSeriesConstructor . . . 3995
UnivariatePuiseuxSeriesConstructor (UPXSCONS) . . . 3999
domain UPXSSING UnivariatePuiseuxSeriesWithExponentialSingularity . . . 4014
UnivariatePuiseuxSeriesWithExponentialSingularity (UPXSSING) . . . 4016
domain OREUP UnivariateSkewPolynomial . . . 4027
UnivariateSkewPolynomial (OREUP) . . . 4039
domain UTS UnivariateTaylorSeries . . . 4041
UnivariateTaylorSeries (UTS) . . . 4044
domain UTSZ UnivariateTaylorSeriesCZero . . . 4056
UnivariateTaylorSeriesCZero (UTSZ) . . . 4059
domain UNISEG UniversalSegment . . . 4070
UniversalSegment (UNISEG) . . . 4073

domain U8MAT U8Matrix 4078
U8Matrix (U8MAT) 4081
domain U16MAT U16Matrix 4084
U16Matrix (U16MAT) 4086
domain U32MAT U32Matrix 4089
U32Matrix (U32MAT) 4092
domain U8VEC U8Vector 4095
U8Vector (U8VEC) 4099
domain U16VEC U16Vector 4102
U16Vector (U16VEC) 4107
domain U32VEC U32Vector 4110
U32Vector (U32VEC) 4115

23 Chapter V 4119
domain VARIABLE Variable 4119
Variable (VARIABLE) 4120
domain VECTOR Vector 4121
Vector (VECTOR) 4127
domain VOID Void 4129
Void (VOID) 4131

24 Chapter W 4133
domain WP WeightedPolynomials 4133
WeightedPolynomials (WP) 4134
domain WUTSET WuWenTsunTriangularSet 4139
WuWenTsunTriangularSet (WUTSET) 4147

25 Chapter X 4157
domain XDPOLY XDistributedPolynomial 4157
XDistributedPolynomial (XDPOLY) 4159
domain XPBWPOLY XPBWPolynomial 4163
XPBWPolynomial (XPBWPOLY) 4180
domain XPOLY XPolynomial 4189
XPolynomial (XPOLY) 4195
domain XPR XPolynomialRing 4196
XPolynomialRing (XPR) 4204
domain XRPOLY XRecursivePolynomial 4210
XRecursivePolynomial (XRPOLY) 4212

26 Chapter Y 4225

27 Chapter Z 4227

28 The bootstrap code **4229**
BOOLEAN.lsp . . . 4229
CHAR.lsp BOOTSTRAP . . . 4234
DFLOAT.lsp BOOTSTRAP . . . 4238
ILIST.lsp BOOTSTRAP . . . 4254
INT.lsp BOOTSTRAP . . . 4266
ISTRING.lsp BOOTSTRAP . . . 4277
LIST.lsp BOOTSTRAP . . . 4295
NNI.lsp BOOTSTRAP . . . 4301
OUTFORM.lsp BOOTSTRAP . . . 4303
PI.lsp BOOTSTRAP . . . 4316
PRIMARR.lsp BOOTSTRAP . . . 4318
REF.lsp BOOTSTRAP . . . 4322
SINT.lsp BOOTSTRAP . . . 4324
SYMBOL.lsp BOOTSTRAP . . . 4337
VECTOR.lsp BOOTSTRAP . . . 4352

29 Chunk collections **4355**

Bibliography **4373**

Index **4387**
chapter*.923

Volume 10.4: Axiom Algebra: Packages

1 Chapter Overview 1

2 Chapter A 3
package AFALGGRO AffineAlgebraicSetComputeWithGroebnerBasis 3
AffineAlgebraicSetComputeWithGroebnerBasis (AFALGGRO) 4
package AFALGRES AffineAlgebraicSetComputeWithResultant 10
AffineAlgebraicSetComputeWithResultant (AFALGRES) 11
package AF AlgebraicFunction 17
AlgebraicFunction (AF) 18
package INTHERAL AlgebraicHermiteIntegration 27
AlgebraicHermiteIntegration (INTHERAL) 27
package INTALG AlgebraicIntegrate 31
AlgebraicIntegrate (INTALG) 32
package INTAF AlgebraicIntegration 43
AlgebraicIntegration (INTAF) 44
package ALGMANIP AlgebraicManipulations 47
AlgebraicManipulations (ALGMANIP) 49
package ALGMFACT AlgebraicMultFact 56
AlgebraicMultFact (ALGMFACT) 57
package ALGPKG AlgebraPackage 59
AlgebraPackage (ALGPKG) 60
package ALGFACT AlgFactor 76
AlgFactor (ALGFACT) 77
package INTPACK AnnaNumericalIntegrationPackage 81
AnnaNumericalIntegrationPackage (INTPACK) 82
package OPTPACK AnnaNumericalOptimizationPackage 97
AnnaNumericalOptimizationPackage (OPTPACK) 98
package ODEPACK AnnaOrdinaryDifferentialEquationPackage 111
AnnaOrdinaryDifferentialEquationPackage (ODEPACK) 112
package PDEPACK AnnaPartialDifferentialEquationPackage 123
AnnaPartialDifferentialEquationPackage (PDEPACK) 124
package ANY1 AnyFunctions1 132
AnyFunctions1 (ANY1) 133
package API ApplicationProgramInterface 135
ApplicationProgramInterface (API) 142
package APPRULE ApplyRules 144
ApplyRules (APPRULE) 145
package APPLYORE ApplyUnivariateSkewPolynomial 150
ApplyUnivariateSkewPolynomial (APPLYORE) 151
package ASSOCEQ AssociatedEquations 152
AssociatedEquations (ASSOCEQ) 153
package PMPRED AttachPredicates 157
AttachPredicates (PMPRED) 158

package AXSERV AxiomServer 160
AxiomServer (AXSERV) 161

3 Chapter B **185**
package BALFACT BalancedFactorisation 185
BalancedFactorisation (BALFACT) 186
package BOP1 BasicOperatorFunctions1 188
BasicOperatorFunctions1 (BOP1) 189
package BEZIER Bezier 194
Bezier (BEZIER) 203
package BEZOUT BezoutMatrix 205
BezoutMatrix (BEZOUT) 207
package BLUPPACK BlowUpPackage 213
BlowUpPackage (BLUPPACK) 214
package BOUNDZRO BoundIntegerRoots 223
BoundIntegerRoots (BOUNDZRO) 224
package BRILL BrillhartTests 227
BrillhartTests (BRILL) 228

4 Chapter C **233**
package CARTEN2 CartesianTensorFunctions2 233
CartesianTensorFunctions2 (CARTEN2) 234
package CHVAR ChangeOfVariable 235
ChangeOfVariable (CHVAR) 236
package CPIMA CharacteristicPolynomialInMonogenicalAlgebra 241
CharacteristicPolynomialInMonogenicalAlgebra (CPIMA) 242
package CHARPOL CharacteristicPolynomialPackage 244
CharacteristicPolynomialPackage (CHARPOL) 245
package IBACHIN ChineseRemainderToolsForIntegralBases 246
ChineseRemainderToolsForIntegralBases (IBACHIN) 247
package CVMP CoerceVectorMatrixPackage 251
CoerceVectorMatrixPackage (CVMP) 252
package COMBF CombinatorialFunction 254
CombinatorialFunction (COMBF) 257
package CDEN CommonDenominator 278
CommonDenominator (CDEN) 279
package COMMONOP CommonOperators 281
CommonOperators (COMMONOP) 282
package COMMUPC CommuteUnivariatePolynomialCategory 293
CommuteUnivariatePolynomialCategory (COMMUPC) 294
package COMPFACT ComplexFactorization 295
ComplexFactorization (COMPFACT) 296
package COMPLEX2 ComplexFunctions2 300
ComplexFunctions2 (COMPLEX2) 301
package CINTSLPE ComplexIntegerSolveLinearPolynomialEquation 302
ComplexIntegerSolveLinearPolynomialEquation (CINTSLPE) 303

package COMPLPAT ComplexPattern . . . 305
ComplexPattern (COMPLPAT) . . . 306
package CPMATCH ComplexPatternMatch . . . 307
ComplexPatternMatch (CPMATCH) . . . 308
package CRFP ComplexRootFindingPackage . . . 310
ComplexRootFindingPackage (CRFP) . . . 312
package CMPLXRT ComplexRootPackage . . . 332
ComplexRootPackage (CMPLXRT) . . . 333
package CTRIGMNP ComplexTrigonometricManipulations . . . 335
ComplexTrigonometricManipulations (CTRIGMNP) . . . 336
package ODECONST ConstantLODE . . . 340
ConstantLODE (ODECONST) . . . 341
package COORDSYS CoordinateSystems . . . 344
CoordinateSystems (COORDSYS) . . . 345
package CRAPACK CRApackage . . . 352
CRApackage (CRAPACK) . . . 353
package CYCLES CycleIndicators . . . 357
CycleIndicators (CYCLES) . . . 374
package CSTTOOLS CyclicStreamTools . . . 382
CyclicStreamTools (CSTTOOLS) . . . 383
package CYCLOTOM CyclotomicPolynomialPackage . . . 385
CyclotomicPolynomialPackage (CYCLOTOM) . . . 386
package CAD CylindricalAlgebraicDecompositionPackage . . . 389
CylindricalAlgebraicDecompositionPackage (CAD) . . . 390
package CADU CylindricalAlgebraicDecompositionUtilities . . . 395
CylindricalAlgebraicDecompositionUtilities (CADU) . . . 396

5 Chapter D 399
package DFINTTLS DefiniteIntegrationTools . . . 399
DefiniteIntegrationTools (DFINTTLS) . . . 400
package DEGRED DegreeReductionPackage . . . 409
DegreeReductionPackage (DEGRED) . . . 410
package DTP DesingTreePackage . . . 412
DesingTreePackage (DTP) . . . 413
package DIOSP DiophantineSolutionPackage . . . 427
DiophantineSolutionPackage (DIOSP) . . . 428
package DIRPROD2 DirectProductFunctions2 . . . 434
DirectProductFunctions2 (DIRPROD2) . . . 435
package DLP DiscreteLogarithmPackage . . . 437
DiscreteLogarithmPackage (DLP) . . . 438
package DISPLAY DisplayPackage . . . 441
DisplayPackage (DISPLAY) . . . 442
package DDFACT DistinctDegreeFactorize . . . 446
DistinctDegreeFactorize (DDFACT) . . . 447
package DFSFUN DoubleFloatSpecialFunctions . . . 456
DoubleFloatSpecialFunctions (DFSFUN) . . . 470

The Gamma Function . . . 475
The Exponential Integral . . . 475
En:(PI,R)→OPR . . . 481
The Ei Function . . . 481
The Fresnel Integral[**?**, **?**] . . . 504
The logGamma Function . . . 507
package DBLRESP DoubleResultantPackage . . . 511
DoubleResultantPackage (DBLRESP) . . . 512
package DRAWCX DrawComplex . . . 514
DrawComplex (DRAWCX) . . . 515
package DRAWHACK DrawNumericHack . . . 522
DrawNumericHack (DRAWHACK) . . . 523
package DROPT0 DrawOptionFunctions0 . . . 524
DrawOptionFunctions0 (DROPT0) . . . 525
package DROPT1 DrawOptionFunctions1 . . . 531
DrawOptionFunctions1 (DROPT1) . . . 532
package D01AGNT d01AgentsPackage . . . 533
d01AgentsPackage (D01AGNT) . . . 555
package D01WGTS d01WeightsPackage . . . 565
d01WeightsPackage (D01WGTS) . . . 566
package D02AGNT d02AgentsPackage . . . 575
d02AgentsPackage (D02AGNT) . . . 599
package D03AGNT d03AgentsPackage . . . 609
d03AgentsPackage (D03AGNT) . . . 624

6 Chapter E **629**
package EP EigenPackage . . . 629
EigenPackage (EP) . . . 630
package EF ElementaryFunction . . . 639
ElementaryFunction (EF) . . . 650
package DEFINTEF ElementaryFunctionDefiniteIntegration . . . 688
ElementaryFunctionDefiniteIntegration (DEFINTEF) . . . 689
package LODEEF ElementaryFunctionLODESolver . . . 697
ElementaryFunctionLODESolver (LODEEF) . . . 698
package ODEEF ElementaryFunctionODESolver . . . 708
ElementaryFunctionODESolver (ODEEF) . . . 709
package SIGNEF ElementaryFunctionSign . . . 718
ElementaryFunctionSign (SIGNEF) . . . 719
package EFSTRUC ElementaryFunctionStructurePackage . . . 726
ElementaryFunctionStructurePackage (EFSTRUC) . . . 727
package INTEF ElementaryIntegration . . . 742
ElementaryIntegration (INTEF) . . . 743
package RDEEF ElementaryRischDE . . . 757
ElementaryRischDE (RDEEF) . . . 758
package RDEEFS ElementaryRischDESystem . . . 771
ElementaryRischDESystem (RDEEFS) . . . 772

package ELFUTS EllipticFunctionsUnivariateTaylorSeries . . . 775
EllipticFunctionsUnivariateTaylorSeries (ELFUTS) . . . 776
package EQ2 EquationFunctions2 . . . 778
EquationFunctions2 (EQ2) . . . 779
package ERROR ErrorFunctions . . . 780
ErrorFunctions (ERROR) . . . 782
package GBEUCLID EuclideanGroebnerBasisPackage . . . 785
EuclideanGroebnerBasisPackage (GBEUCLID) . . . 806
package EVALCYC EvaluateCycleIndicators . . . 825
EvaluateCycleIndicators (EVALCYC) . . . 826
package ESCONT ExpertSystemContinuityPackage . . . 827
ExpertSystemContinuityPackage (ESCONT) . . . 829
package ESCONT1 ExpertSystemContinuityPackage1 . . . 838
ExpertSystemContinuityPackage1 (ESCONT1) . . . 839
package ESTOOLS ExpertSystemToolsPackage . . . 840
ExpertSystemToolsPackage (ESTOOLS) . . . 842
package ESTOOLS1 ExpertSystemToolsPackage1 . . . 855
ExpertSystemToolsPackage1 (ESTOOLS1) . . . 856
package ESTOOLS2 ExpertSystemToolsPackage2 . . . 857
ExpertSystemToolsPackage2 (ESTOOLS2) . . . 858
package EXPR2 ExpressionFunctions2 . . . 859
ExpressionFunctions2 (EXPR2) . . . 860
package EXPRSOL ExpressionSolve . . . 861
Bugs . . . 861
ExpressionSolve (EXPRSOL) . . . 863
package ES1 ExpressionSpaceFunctions1 . . . 865
ExpressionSpaceFunctions1 (ES1) . . . 866
package ES2 ExpressionSpaceFunctions2 . . . 868
ExpressionSpaceFunctions2 (ES2) . . . 869
package EXPRODE ExpressionSpaceODESolver . . . 870
ExpressionSpaceODESolver (EXPRODE) . . . 871
package OMEXPR ExpressionToOpenMath . . . 878
ExpressionToOpenMath (OMEXPR) . . . 879
package EXPR2UPS ExpressionToUnivariatePowerSeries . . . 890
ExpressionToUnivariatePowerSeries (EXPR2UPS) . . . 891
package EXPRTUBE ExpressionTubePlot . . . 903
ExpressionTubePlot (EXPRTUBE) . . . 904
package EXP3D Export3D . . . 910
Export3D (EXP3D) . . . 911
package E04AGNT e04AgentsPackage . . . 915
e04AgentsPackage (E04AGNT) . . . 917

7 Chapter F **927**
package FACTFUNC FactoredFunctions . . . 927
FactoredFunctions (FACTFUNC) . . . 928
package FR2 FactoredFunctions2 . . . 930
FactoredFunctions2 (FR2) . . . 933
package FRUTIL FactoredFunctionUtilities . . . 934
FactoredFunctionUtilities (FRUTIL) . . . 935
package FACUTIL FactoringUtilities . . . 937
FactoringUtilities (FACUTIL) . . . 938
package FACTEXT FactorisationOverPseudoAlgebraicClosureOfAlgExtOfRational-Number . . . 942
FactorisationOverPseudoAlgebraicClosureOfAlgExtOfRationalNumber (FACTEXT) . . . 943
package FACTRN FactorisationOverPseudoAlgebraicClosureOfRationalNumber . . . 948
FactorisationOverPseudoAlgebraicClosureOfRationalNumber (FACTRN) . . . 949
package FGLMICPK FGLMIfCanPackage . . . 954
FGLMIfCanPackage (FGLMICPK) . . . 955
package FORDER FindOrderFinite . . . 958
FindOrderFinite (FORDER) . . . 959
package FAMR2 FiniteAbelianMonoidRingFunctions2 . . . 960
FiniteAbelianMonoidRingFunctions2 (FAMR2) . . . 961
package FDIV2 FiniteDivisorFunctions2 . . . 962
FiniteDivisorFunctions2 (FDIV2) . . . 963
package FFFACTOR FiniteFieldFactorization . . . 965
FiniteFieldFactorization (FFFACTOR) . . . 966
package FFFACTSE FiniteFieldFactorizationWithSizeParseBySideEffect . . . 974
FiniteFieldFactorizationWithSizeParseBySideEffect (FFFACTSE) . . . 976
package FFF FiniteFieldFunctions . . . 985
FiniteFieldFunctions (FFF) . . . 986
package FFHOM FiniteFieldHomomorphisms . . . 994
FiniteFieldHomomorphisms (FFHOM) . . . 995
package FFPOLY FiniteFieldPolynomialPackage . . . 1008
FiniteFieldPolynomialPackage (FFPOLY) . . . 1009
package FFPOLY2 FiniteFieldPolynomialPackage2 . . . 1042
FiniteFieldPolynomialPackage2 (FFPOLY2) . . . 1043
package FFSLPE FiniteFieldSolveLinearPolynomialEquation . . . 1047
FiniteFieldSolveLinearPolynomialEquation (FFSLPE) . . . 1048
package FFSQFR FiniteFieldSquareFreeDecomposition . . . 1050
FiniteFieldSquareFreeDecomposition (FFSQFR) . . . 1051
package FLAGG2 FiniteLinearAggregateFunctions2 . . . 1055
FiniteLinearAggregateFunctions2 (FLAGG2) . . . 1056
package FLASORT FiniteLinearAggregateSort . . . 1061
FiniteLinearAggregateSort (FLASORT) . . . 1062
package FSAGG2 FiniteSetAggregateFunctions2 . . . 1065
FiniteSetAggregateFunctions2 (FSAGG2) . . . 1067
package FLOATCP FloatingComplexPackage . . . 1069

FloatingComplexPackage (FLOATCP) . . . 1070
package FLOATRP FloatingRealPackage . . . 1073
FloatingRealPackage (FLOATRP) . . . 1075
package FSFUN FloatSpecialFunctions . . . 1078
FloatSpecialFunctions (FSFUN) . . . 1080
The Gamma Function . . . 1082
The logGamma Function . . . 1084
package FCPAK1 FortranCodePackage1 . . . 1088
FortranCodePackage1 (FCPAK1) . . . 1089
package FOP FortranOutputStackPackage . . . 1094
FortranOutputStackPackage (FOP) . . . 1095
package FORT FortranPackage . . . 1098
FortranPackage (FORT) . . . 1099
package FRIDEAL2 FractionalIdealFunctions2 . . . 1103
FractionalIdealFunctions2 (FRIDEAL2) . . . 1104
package FFFG FractionFreeFastGaussian . . . 1105
FractionFreeFastGaussian (FFFG) . . . 1107
package FFFGF FractionFreeFastGaussianFractions . . . 1121
FractionFreeFastGaussianFractions (FFFGF) . . . 1122
package FRAC2 FractionFunctions2 . . . 1125
FractionFunctions2 (FRAC2) . . . 1126
package FRNAAF2 FramedNonAssociativeAlgebraFunctions2 . . . 1127
FramedNonAssociativeAlgebraFunctions2 (FRNAAF2) . . . 1128
package FSPECF FunctionalSpecialFunction . . . 1130
FunctionalSpecialFunction (FSPECF) . . . 1131
differentiation of special functions . . . 1137
package FFCAT2 FunctionFieldCategoryFunctions2 . . . 1146
FunctionFieldCategoryFunctions2 (FFCAT2) . . . 1147
package FFINTBAS FunctionFieldIntegralBasis . . . 1148
FunctionFieldIntegralBasis (FFINTBAS) . . . 1150
package PMASSFS FunctionSpaceAssertions . . . 1154
FunctionSpaceAssertions (PMASSFS) . . . 1155
package PMPREDFS FunctionSpaceAttachPredicates . . . 1157
FunctionSpaceAttachPredicates (PMPREDFS) . . . 1159
package FSCINT FunctionSpaceComplexIntegration . . . 1161
FunctionSpaceComplexIntegration (FSCINT) . . . 1162
package FS2 FunctionSpaceFunctions2 . . . 1165
FunctionSpaceFunctions2 (FS2) . . . 1166
package FSINT FunctionSpaceIntegration . . . 1168
FunctionSpaceIntegration (FSINT) . . . 1169
package FSPRMELT FunctionSpacePrimitiveElement . . . 1174
FunctionSpacePrimitiveElement (FSPRMELT) . . . 1175
package FSRED FunctionSpaceReduce . . . 1179
FunctionSpaceReduce (FSRED) . . . 1180
package SUMFS FunctionSpaceSum . . . 1182
FunctionSpaceSum (SUMFS) . . . 1183

package FS2EXPXP FunctionSpaceToExponentialExpansion 1185
FunctionSpaceToExponentialExpansion (FS2EXPXP) 1187
package FS2UPS FunctionSpaceToUnivariatePowerSeries 1206
FunctionSpaceToUnivariatePowerSeries (FS2UPS) 1208
package FSUPFACT FunctionSpaceUnivariatePolynomialFactor 1234
FunctionSpaceUnivariatePolynomialFactor (FSUPFACT) 1235

8 Chapter G **1243**
package GALFACTU GaloisGroupFactorizationUtilities 1243
GaloisGroupFactorizationUtilities (GALFACTU) 1244
package GALFACT GaloisGroupFactorizer 1249
GaloisGroupFactorizer (GALFACT) 1251
package GALPOLYU GaloisGroupPolynomialUtilities 1278
GaloisGroupPolynomialUtilities (GALPOLYU) 1279
package GALUTIL GaloisGroupUtilities 1283
GaloisGroupUtilities (GALUTIL) 1284
package GAUSSFAC GaussianFactorizationPackage 1288
GaussianFactorizationPackage (GAUSSFAC) 1289
package GHENSEL GeneralHenselPackage 1295
GeneralHenselPackage (GHENSEL) 1296
package GENMFACT GeneralizedMultivariateFactorize 1302
GeneralizedMultivariateFactorize (GENMFACT) 1303
package GPAFF GeneralPackageForAlgebraicFunctionField 1305
GeneralPackageForAlgebraicFunctionField (GPAFF) 1309
package GENPGCD GeneralPolynomialGcdPackage 1331
GeneralPolynomialGcdPackage (GENPGCD) 1332
package GENUPS GenerateUnivariatePowerSeries 1348
GenerateUnivariatePowerSeries (GENUPS) 1349
package GENEEZ GenExEuclid 1356
GenExEuclid (GENEEZ) 1357
package GENUFACT GenUFactorize 1365
GenUFactorize (GENUFACT) 1366
package INTG0 GenusZeroIntegration 1368
GenusZeroIntegration (INTG0) 1370
package GDRAW GnuDraw 1379
GnuDraw (GDRAW) 1380
package GOSPER GosperSummationMethod 1384
GosperSummationMethod (GOSPER) 1385
package GRDEF GraphicsDefaults 1393
GraphicsDefaults (GRDEF) 1394
package GRAPHVIZ Graphviz 1397
Graphviz (GRAPHVIZ) 1400
package GRAY GrayCode 1404
GrayCode (GRAY) 1405
package GBF GroebnerFactorizationPackage 1406
GroebnerFactorizationPackage (GBF) 1411

package GBINTERN GroebnerInternalPackage . . . 1423
GroebnerInternalPackage (GBINTERN) . . . 1424
package GB GroebnerPackage . . . 1441
GroebnerPackage (GB) . . . 1468
package GROEBSOL GroebnerSolve . . . 1472
GroebnerSolve (GROEBSOL) . . . 1473
package GUESS Guess . . . 1480
Guess (GUESS) . . . 1482
package GUESSAN GuessAlgebraicNumber . . . 1514
GuessAlgebraicNumber (GUESSAN) . . . 1516
package GUESSF GuessFinite . . . 1517
GuessFinite (GUESSF) . . . 1518
package GUESSF1 GuessFiniteFunctions . . . 1519
GuessFiniteFunctions (GUESSF1) . . . 1520
package GUESSINT GuessInteger . . . 1521
GuessInteger (GUESSINT) . . . 1523
package GUESSP GuessPolynomial . . . 1524
GuessPolynomial (GUESSP) . . . 1525
package GUESSUP GuessUnivariatePolynomial . . . 1526
GuessUnivariatePolynomial (GUESSUP) . . . 1528

9 Chapter H 1533
package HB HallBasis . . . 1533
HallBasis (HB) . . . 1534
package HEUGCD HeuGcd . . . 1537
HeuGcd (HEUGCD) . . . 1538

10 Chapter I 1547
package IDECOMP IdealDecompositionPackage . . . 1547
IdealDecompositionPackage (IDECOMP) . . . 1548
package INCRMAPS IncrementingMaps . . . 1562
IncrementingMaps (INCRMAPS) . . . 1563
package INFPROD0 InfiniteProductCharacteristicZero . . . 1564
InfiniteProductCharacteristicZero (INFPROD0) . . . 1565
package INPRODFF InfiniteProductFiniteField . . . 1567
InfiniteProductFiniteField (INPRODFF) . . . 1568
package INPRODPF InfiniteProductPrimeField . . . 1572
InfiniteProductPrimeField (INPRODPF) . . . 1573
package ITFUN2 InfiniteTupleFunctions2 . . . 1575
InfiniteTupleFunctions2 (ITFUN2) . . . 1576
package ITFUN3 InfiniteTupleFunctions3 . . . 1577
InfiniteTupleFunctions3 (ITFUN3) . . . 1578
package INFINITY Infinity . . . 1579
Infinity (INFINITY) . . . 1580
package IALGFACT InnerAlgFactor . . . 1582
InnerAlgFactor (IALGFACT) . . . 1583

package ICDEN InnerCommonDenominator 1586
InnerCommonDenominator (ICDEN) 1587
package IMATLIN InnerMatrixLinearAlgebraFunctions 1589
InnerMatrixLinearAlgebraFunctions (IMATLIN) 1590
package IMATQF InnerMatrixQuotientFieldFunctions 1598
InnerMatrixQuotientFieldFunctions (IMATQF) 1599
package INMODGCD InnerModularGcd 1601
InnerModularGcd (INMODGCD) 1602
package INNMFACT InnerMultFact 1608
InnerMultFact (INNMFACT) 1609
package INBFF InnerNormalBasisFieldFunctions 1624
InnerNormalBasisFieldFunctions (INBFF) 1625
package INEP InnerNumericEigenPackage 1637
InnerNumericEigenPackage (INEP) 1638
package INFSP InnerNumericFloatSolvePackage 1644
InnerNumericFloatSolvePackage (INFSP) 1646
package INPSIGN InnerPolySign 1652
InnerPolySign (INPSIGN) 1653
package ISUMP InnerPolySum 1655
InnerPolySum (ISUMP) 1656
package ITRIGMNP InnerTrigonometricManipulations 1658
InnerTrigonometricManipulations (ITRIGMNP) 1659
package INFORM1 InputFormFunctions1 1665
InputFormFunctions1 (INFORM1) 1666
package INTERGB InterfaceGroebnerPackage 1668
InterfaceGroebnerPackage (INTERGB) 1669
IntegerBits (INTBIT) 1673
package COMBINAT IntegerCombinatoricFunctions 1674
IntegerCombinatoricFunctions (COMBINAT) 1677
package INTFACT IntegerFactorizationPackage 1682
IntegerFactorizationPackage (INTFACT) 1683
squareFree 1684
PollardSmallFactor 1685
BasicSieve 1687
BasicMethod 1687
factor 1688
package ZLINDEP IntegerLinearDependence 1692
IntegerLinearDependence (ZLINDEP) 1695
package INTHEORY IntegerNumberTheoryFunctions 1697
IntegerNumberTheoryFunctions (INTHEORY) 1710
package PRIMES IntegerPrimesPackage 1719
IntegerPrimesPackage (PRIMES) 1720
Rabin-Miller testing 1720
smallPrimes 1723
primes 1727
rabinProvesCompositeSmall 1727

rabinProvesComposite . . . 1728
prime? . . . 1728
nextPrime . . . 1730
prevPrime . . . 1730
package INTRET IntegerRetractions . . . 1737
IntegerRetractions (INTRET) . . . 1738
package IROOT IntegerRoots . . . 1739
IntegerRoots (IROOT) . . . 1741
perfectSquare? . . . 1742
perfectNthPower? . . . 1742
perfectNthRoot . . . 1742
approxNthRoot . . . 1743
perfectNthRoot . . . 1743
perfectSqrt . . . 1744
approxSqrt . . . 1744
package INTSLPE IntegerSolveLinearPolynomialEquation . . . 1746
IntegerSolveLinearPolynomialEquation (INTSLPE) . . . 1747
package IBATOOL IntegralBasisTools . . . 1749
IntegralBasisTools (IBATOOL) . . . 1750
package IBPTOOLS IntegralBasisPolynomialTools . . . 1755
IntegralBasisPolynomialTools (IBPTOOLS) . . . 1756
package IR2 IntegrationResultFunctions2 . . . 1759
IntegrationResultFunctions2 (IR2) . . . 1760
package IRRF2F IntegrationResultRFToFunction . . . 1763
IntegrationResultRFToFunction (IRRF2F) . . . 1764
package IR2F IntegrationResultToFunction . . . 1767
IntegrationResultToFunction (IR2F) . . . 1768
package INTTOOLS IntegrationTools . . . 1776
IntegrationTools (INTTOOLS) . . . 1777
package IPRNTPK InternalPrintPackage . . . 1782
InternalPrintPackage (IPRNTPK) . . . 1783
package IRURPK InternalRationalUnivariateRepresentationPackage . . . 1784
InternalRationalUnivariateRepresentationPackage (IRURPK) . . . 1785
package INTFRSP InterpolateFormsPackage . . . 1792
InterpolateFormsPackage (INTFRSP) . . . 1793
package INTDIVP IntersectionDivisorPackage . . . 1799
IntersectionDivisorPackage (INTDIVP) . . . 1800
package IRREDFFX IrredPolyOverFiniteField . . . 1804
IrredPolyOverFiniteField (IRREDFFX) . . . 1805
package IRSN IrrRepSymNatPackage . . . 1807
IrrRepSymNatPackage (IRSN) . . . 1809
package INVLAPLA InverseLaplaceTransform . . . 1819
InverseLaplaceTransform (INVLAPLA) . . . 1820

11 Chapter J 1825

12 Chapter K **1827**
package KERNEL2 KernelFunctions2 1827
KernelFunctions2 (KERNEL2) 1828
package KOVACIC Kovacic 1829
Kovacic (KOVACIC) 1830

13 Chapter L **1835**
package LAPLACE LaplaceTransform 1835
LaplaceTransform (LAPLACE) 1836
package LAZM3PK LazardSetSolvingPackage 1843
LazardSetSolvingPackage (LAZM3PK) 1863
package LEADCDET LeadingCoefDetermination 1867
LeadingCoefDetermination (LEADCDET) 1868
package LEXTRIPK LexTriangularPackage 1872
LexTriangularPackage (LEXTRIPK) 1937
package LINDEP LinearDependence 1944
LinearDependence (LINDEP) 1945
package LODOF LinearOrdinaryDifferentialOperatorFactorizer 1948
LinearOrdinaryDifferentialOperatorFactorizer (LODOF) 1949
package LODOOPS LinearOrdinaryDifferentialOperatorsOps 1954
LinearOrdinaryDifferentialOperatorsOps (LODOOPS) 1955
package LPEFRAC LinearPolynomialEquationByFractions 1959
LinearPolynomialEquationByFractions (LPEFRAC) 1960
package LISYSER LinearSystemFromPowerSeriesPackage 1962
LinearSystemFromPowerSeriesPackage (LISYSER) 1963
package LSMP LinearSystemMatrixPackage 1966
LinearSystemMatrixPackage (LSMP) 1967
package LSMP1 LinearSystemMatrixPackage1 1970
LinearSystemMatrixPackage1 (LSMP1) 1971
package LSPP LinearSystemPolynomialPackage 1974
LinearSystemPolynomialPackage (LSPP) 1975
package LGROBP LinGroebnerPackage 1977
LinGroebnerPackage (LGROBP) 1978
package LOP LinesOpPack 1990
LinesOpPack (LOP) 1991
package LF LiouvillianFunction 1995
LiouvillianFunction (LF) 1996
package LIST2 ListFunctions2 2004
ListFunctions2 (LIST2) 2005
package LIST3 ListFunctions3 2007
ListFunctions3 (LIST3) 2008
package LIST2MAP ListToMap 2009
ListToMap (LIST2MAP) 2011
package LPARSPT LocalParametrizationOfSimplePointPackage 2014
LocalParametrizationOfSimplePointPackage (LPARSPT) 2015

14 Chapter M **2025**
package MKBCFUNC MakeBinaryCompiledFunction . . . 2025
MakeBinaryCompiledFunction (MKBCFUNC) . . . 2027
package MKFLCFN MakeFloatCompiledFunction . . . 2029
MakeFloatCompiledFunction (MKFLCFN) . . . 2030
package MKFUNC MakeFunction . . . 2034
MakeFunction (MKFUNC) . . . 2039
package MKRECORD MakeRecord . . . 2041
MakeRecord (MKRECORD) . . . 2042
package MKUCFUNC MakeUnaryCompiledFunction . . . 2043
MakeUnaryCompiledFunction (MKUCFUNC) . . . 2045
package MAPHACK1 MappingPackageInternalHacks1 . . . 2047
MappingPackageInternalHacks1 (MAPHACK1) . . . 2048
package MAPHACK2 MappingPackageInternalHacks2 . . . 2049
MappingPackageInternalHacks2 (MAPHACK2) . . . 2050
package MAPHACK3 MappingPackageInternalHacks3 . . . 2051
MappingPackageInternalHacks3 (MAPHACK3) . . . 2052
package MAPPKG1 MappingPackage1 . . . 2053
MappingPackage1 (MAPPKG1) . . . 2062
package MAPPKG2 MappingPackage2 . . . 2065
MappingPackage2 (MAPPKG2) . . . 2073
package MAPPKG3 MappingPackage3 . . . 2075
MappingPackage3 (MAPPKG3) . . . 2083
package MAPPKG4 MappingPackage4 . . . 2086
MappingPackage4 (MAPPKG4) . . . 2091
package MATCAT2 MatrixCategoryFunctions2 . . . 2094
MatrixCategoryFunctions2 (MATCAT2) . . . 2095
package MCDEN MatrixCommonDenominator . . . 2097
MatrixCommonDenominator (MCDEN) . . . 2098
package MATLIN MatrixLinearAlgebraFunctions . . . 2100
MatrixLinearAlgebraFunctions (MATLIN) . . . 2101
package MAMA MatrixManipulation . . . 2114
MatrixManipulation (MAMA) . . . 2154
package MTHING MergeThing . . . 2165
MergeThing (MTHING) . . . 2166
package MESH MeshCreationRoutinesForThreeDimensions . . . 2168
MeshCreationRoutinesForThreeDimensions (MESH) . . . 2169
package MDDFACT ModularDistinctDegreeFactorizer . . . 2175
ModularDistinctDegreeFactorizer (MDDFACT) . . . 2176
package MHROWRED ModularHermitianRowReduction . . . 2184
ModularHermitianRowReduction (MHROWRED) . . . 2185
package MRF2 MonoidRingFunctions2 . . . 2194
MonoidRingFunctions2 (MRF2) . . . 2195
package MONOTOOL MonomialExtensionTools . . . 2196
MonomialExtensionTools (MONOTOOL) . . . 2198
package MSYSCMD MoreSystemCommands . . . 2200

MoreSystemCommands (MSYSCMD) . . . 2202
package MPCPF MPolyCatPolyFactorizer . . . 2203
MPolyCatPolyFactorizer (MPCPF) . . . 2204
package MPRFF MPolyCatRationalFunctionFactorizer . . . 2206
MPolyCatRationalFunctionFactorizer (MPRFF) . . . 2207
package MPC2 MPolyCatFunctions2 . . . 2212
MPolyCatFunctions2 (MPC2) . . . 2213
package MPC3 MPolyCatFunctions3 . . . 2215
MPolyCatFunctions3 (MPC3) . . . 2216
package MRATFAC MRationalFactorize . . . 2217
MRationalFactorize (MRATFAC) . . . 2218
package MFINFACT MultFiniteFactorize . . . 2220
MultFiniteFactorize (MFINFACT) . . . 2221
package MMAP MultipleMap . . . 2238
MultipleMap (MMAP) . . . 2239
package MCALCFN MultiVariableCalculusFunctions . . . 2241
MultiVariableCalculusFunctions (MCALCFN) . . . 2242
package MULTFACT MultivariateFactorize . . . 2247
MultivariateFactorize (MULTFACT) . . . 2248
package MLIFT MultivariateLifting . . . 2250
package MULTSQFR MultivariateSquareFree . . . 2259
MultivariateSquareFree (MULTSQFR) . . . 2260

15 Chapter N 2273
package NAGF02 NagEigenPackage . . . 2273
NagEigenPackage (NAGF02) . . . 2363
package NAGE02 NagFittingPackage . . . 2384
NagFittingPackage (NAGE02) . . . 2544
package NAGF04 NagLinearEquationSolvingPackage . . . 2565
NagLinearEquationSolvingPackage (NAGF04) . . . 2655
package NAGSP NAGLinkSupportPackage . . . 2669
NAGLinkSupportPackage (NAGSP) . . . 2670
package NAGD01 NagIntegrationPackage . . . 2673
NagIntegrationPackage (NAGD01) . . . 2745
package NAGE01 NagInterpolationPackage . . . 2760
NagInterpolationPackage (NAGE01) . . . 2813
package NAGF07 NagLapack . . . 2824
NagLapack (NAGF07) . . . 2844
package NAGF01 NagMatrixOperationsPackage . . . 2848
NagMatrixOperationsPackage (NAGF01) . . . 2924
package NAGE04 NagOptimisationPackage . . . 2936
NagOptimisationPackage (NAGE04) . . . 3109
package NAGD02 NagOrdinaryDifferentialEquationsPackage . . . 3123
NagOrdinaryDifferentialEquationsPackage (NAGD02) . . . 3207
package NAGD03 NagPartialDifferentialEquationsPackage . . . 3225
NagPartialDifferentialEquationsPackage (NAGD03) . . . 3258

package NAGC02 NagPolynomialRootsPackage . . . 3264
NagPolynomialRootsPackage (NAGC02) . . . 3280
package NAGC05 NagRootFindingPackage . . . 3283
NagRootFindingPackage (NAGC05) . . . 3303
package NAGC06 NagSeriesSummationPackage . . . 3307
NagSeriesSummationPackage (NAGC06) . . . 3365
package NAGS NagSpecialFunctionsPackage . . . 3375
NagSpecialFunctionsPackage (NAGS) . . . 3515
package NSUP2 NewSparseUnivariatePolynomialFunctions2 . . . 3542
NewSparseUnivariatePolynomialFunctions2 (NSUP2) . . . 3543
package NEWTON NewtonInterpolation . . . 3544
NewtonInterpolation (NEWTON) . . . 3545
package NPOLYGON NewtonPolygon . . . 3547
NewtonPolygon (NPOLYGON) . . . 3548
package NCODIV NonCommutativeOperatorDivision . . . 3555
NonCommutativeOperatorDivision (NCODIV) . . . 3557
package NONE1 NoneFunctions1 . . . 3560
NoneFunctions1 (NONE1) . . . 3561
package NODE1 NonLinearFirstOrderODESolver . . . 3562
NonLinearFirstOrderODESolver (NODE1) . . . 3563
package NLINSOL NonLinearSolvePackage . . . 3569
NonLinearSolvePackage (NLINSOL) . . . 3570
package NORMPK NormalizationPackage . . . 3574
NormalizationPackage (NORMPK) . . . 3575
package NORMMA NormInMonogenicAlgebra . . . 3582
NormInMonogenicAlgebra (NORMMA) . . . 3583
package NORMRETR NormRetractPackage . . . 3584
NormRetractPackage (NORMRETR) . . . 3585
package NPCOEF NPCoef . . . 3588
NPCoef (NPCOEF) . . . 3589
package NFINTBAS NumberFieldIntegralBasis . . . 3595
NumberFieldIntegralBasis (NFINTBAS) . . . 3596
package NUMFMT NumberFormats . . . 3603
NumberFormats (NUMFMT) . . . 3605
package NTPOLFN NumberTheoreticPolynomialFunctions . . . 3612
NumberTheoreticPolynomialFunctions (NTPOLFN) . . . 3613
package NUMERIC Numeric . . . 3616
Numeric (NUMERIC) . . . 3618
package NUMODE NumericalOrdinaryDifferentialEquations . . . 3635
NumericalOrdinaryDifferentialEquations (NUMODE) . . . 3638
package NUMQUAD NumericalQuadrature . . . 3649
NumericalQuadrature (NUMQUAD) . . . 3651
package NCEP NumericComplexEigenPackage . . . 3668
NumericComplexEigenPackage (NCEP) . . . 3669
package NCNTFRAC NumericContinuedFraction . . . 3671
NumericContinuedFraction (NCNTFRAC) . . . 3672

package NREP NumericRealEigenPackage 3674
NumericRealEigenPackage (NREP) 3675
package NUMTUBE NumericTubePlot 3677
NumericTubePlot (NUMTUBE) 3678

16 Chapter O **3683**
package OCTCT2 OctonionCategoryFunctions2 3683
OctonionCategoryFunctions2 (OCTCT2) 3684
package ODEINT ODEIntegration 3685
ODEIntegration (ODEINT) 3686
package ODETOOLS ODETools 3690
ODETools (ODETOOLS) 3691
package ARRAY12 OneDimensionalArrayFunctions2 3693
OneDimensionalArrayFunctions2 (ARRAY12) 3694
package ONECOMP2 OnePointCompletionFunctions2 3696
OnePointCompletionFunctions2 (ONECOMP2) 3697
package OMPKG OpenMathPackage 3699
OpenMathPackage (OMPKG) 3700
package OMSERVER OpenMathServerPackage 3703
OpenMathServerPackage (OMSERVER) 3704
package OPQUERY OperationsQuery 3706
OperationsQuery (OPQUERY) 3707
package ORDCOMP2 OrderedCompletionFunctions2 3708
OrderedCompletionFunctions2 (ORDCOMP2) 3709
package ORDFUNS OrderingFunctions 3711
OrderingFunctions (ORDFUNS) 3715
package ORTHPOL OrthogonalPolynomialFunctions 3717
OrthogonalPolynomialFunctions (ORTHPOL) 3718
package OUT OutputPackage 3722
OutputPackage (OUT) 3723

17 Chapter P **3727**
package PAFF PackageForAlgebraicFunctionField 3727
PackageForAlgebraicFunctionField (PAFF) 3731
package PAFFFF PackageForAlgebraicFunctionFieldOverFiniteField 3740
PackageForAlgebraicFunctionFieldOverFiniteField (PAFFFF) 3773
package PFORP PackageForPoly 3789
PackageForPoly (PFORP) 3791
package PADEPAC PadeApproximantPackage 3801
PadeApproximantPackage (PADEPAC) 3802
package PADE PadeApproximants 3804
PadeApproximants (PADE) 3805
package PWFFINTB PAdicWildFunctionFieldIntegralBasis 3810
PAdicWildFunctionFieldIntegralBasis (PWFFINTB) 3812
package YSTREAM ParadoxicalCombinatorsForStreams 3820
ParadoxicalCombinatorsForStreams (YSTREAM) 3821

package PLEQN ParametricLinearEquations . . . 3823
ParametricLinearEquations (PLEQN) . . . 3825
package PARPC2 ParametricPlaneCurveFunctions2 . . . 3845
ParametricPlaneCurveFunctions2 (PARPC2) . . . 3846
package PARSC2 ParametricSpaceCurveFunctions2 . . . 3847
ParametricSpaceCurveFunctions2 (PARSC2) . . . 3848
package PARSU2 ParametricSurfaceFunctions2 . . . 3849
ParametricSurfaceFunctions2 (PARSU2) . . . 3850
package PARAMP ParametrizationPackage . . . 3851
ParametrizationPackage (PARAMP) . . . 3852
package PFRPAC PartialFractionPackage . . . 3855
PartialFractionPackage (PFRPAC) . . . 3857
package PARTPERM PartitionsAndPermutations . . . 3860
PartitionsAndPermutations (PARTPERM) . . . 3861
package PATTERN1 PatternFunctions1 . . . 3865
PatternFunctions1 (PATTERN1) . . . 3866
package PATTERN2 PatternFunctions2 . . . 3869
PatternFunctions2 (PATTERN2) . . . 3870
package PATMATCH PatternMatch . . . 3872
PatternMatch (PATMATCH) . . . 3873
package PMASS PatternMatchAssertions . . . 3876
PatternMatchAssertions (PMASS) . . . 3877
package PMFS PatternMatchFunctionSpace . . . 3878
PatternMatchFunctionSpace (PMFS) . . . 3880
package PMINS PatternMatchIntegerNumberSystem . . . 3883
PatternMatchIntegerNumberSystem (PMINS) . . . 3884
package INTPM PatternMatchIntegration . . . 3887
PatternMatchIntegration (INTPM) . . . 3888
package PMKERNEL PatternMatchKernel . . . 3900
PatternMatchKernel (PMKERNEL) . . . 3901
package PMLSAGG PatternMatchListAggregate . . . 3905
PatternMatchListAggregate (PMLSAGG) . . . 3906
package PMPLCAT PatternMatchPolynomialCategory . . . 3908
PatternMatchPolynomialCategory (PMPLCAT) . . . 3909
package PMDOWN PatternMatchPushDown . . . 3912
PatternMatchPushDown (PMDOWN) . . . 3913
package PMQFCAT PatternMatchQuotientFieldCategory . . . 3917
PatternMatchQuotientFieldCategory (PMQFCAT) . . . 3918
package PATRES2 PatternMatchResultFunctions2 . . . 3919
PatternMatchResultFunctions2 (PATRES2) . . . 3920
package PMSYM PatternMatchSymbol . . . 3921
PatternMatchSymbol (PMSYM) . . . 3922
package PMTOOLS PatternMatchTools . . . 3924
PatternMatchTools (PMTOOLS) . . . 3925
package PERMAN Permanent . . . 3931
Permanent (PERMAN) . . . 3933

package PGE PermutationGroupExamples . . . 3939
PermutationGroupExamples (PGE) . . . 3941
package PICOERCE PiCoercions . . . 3953
PiCoercions (PICOERCE) . . . 3954
package PLOT1 PlotFunctions1 . . . 3956
PlotFunctions1 (PLOT1) . . . 3957
package PLOTTOOL PlotTools . . . 3959
PlotTools (PLOTTOOL) . . . 3960
package PRJALGPK ProjectiveAlgebraicSetPackage . . . 3963
ProjectiveAlgebraicSetPackage (PRJALGPK) . . . 3964
package PTFUNC2 PointFunctions2 . . . 3970
PointFunctions2 (PTFUNC2) . . . 3971
package PTPACK PointPackage . . . 3972
PointPackage (PTPACK) . . . 3973
package PFO PointsOfFiniteOrder . . . 3976
PointsOfFiniteOrder (PFO) . . . 3977
package PFOQ PointsOfFiniteOrderRational . . . 3988
PointsOfFiniteOrderRational (PFOQ) . . . 3989
package PFOTOOLS PointsOfFiniteOrderTools . . . 3992
PointsOfFiniteOrderTools (PFOTOOLS) . . . 3993
package PLPKCRV PolynomialPackageForCurve . . . 3995
PolynomialPackageForCurve (PLPKCRV) . . . 3996
package POLTOPOL PolToPol . . . 4000
PolToPol (POLTOPOL) . . . 4001
package PGROEB PolyGroebner . . . 4003
PolyGroebner (PGROEB) . . . 4005
package PAN2EXPR PolynomialAN2Expression . . . 4008
PolynomialAN2Expression (PAN2EXPR) . . . 4009
package POLYLIFT PolynomialCategoryLifting . . . 4010
PolynomialCategoryLifting (POLYLIFT) . . . 4011
package POLYCATQ PolynomialCategoryQuotientFunctions . . . 4013
PolynomialCategoryQuotientFunctions (POLYCATQ) . . . 4014
package PCOMP PolynomialComposition . . . 4019
PolynomialComposition (PCOMP) . . . 4020
package PDECOMP PolynomialDecomposition . . . 4021
PolynomialDecomposition (PDECOMP) . . . 4022
package PFBR PolynomialFactorizationByRecursion . . . 4025
PolynomialFactorizationByRecursion (PFBR) . . . 4026
package PFBRU PolynomialFactorizationByRecursionUnivariate . . . 4038
PolynomialFactorizationByRecursionUnivariate (PFBRU) . . . 4039
package POLY2 PolynomialFunctions2 . . . 4049
PolynomialFunctions2 (POLY2) . . . 4050
package PGCD PolynomialGcdPackage . . . 4051
PolynomialGcdPackage (PGCD) . . . 4052
package PINTERP PolynomialInterpolation . . . 4068
PolynomialInterpolation (PINTERP) . . . 4069

package PINTERPA PolynomialInterpolationAlgorithms 4070
PolynomialInterpolationAlgorithms (PINTERPA) 4071
package PNTHEORY PolynomialNumberTheoryFunctions 4073
PolynomialNumberTheoryFunctions (PNTHEORY) 4074
package POLYROOT PolynomialRoots 4081
PolynomialRoots (POLYROOT) 4082
package PSETPK PolynomialSetUtilitiesPackage 4088
PolynomialSetUtilitiesPackage (PSETPK) 4089
package SOLVEFOR PolynomialSolveByFormulas 4118
PolynomialSolveByFormulas (SOLVEFOR) 4119
package PSQFR PolynomialSquareFree 4129
PolynomialSquareFree (PSQFR) 4130
package POLY2UP PolynomialToUnivariatePolynomial 4135
PolynomialToUnivariatePolynomial (POLY2UP) 4136
package LIMITPS PowerSeriesLimitPackage 4137
PowerSeriesLimitPackage (LIMITPS) 4138
package PREASSOC PrecomputedAssociatedEquations 4157
PrecomputedAssociatedEquations (PREASSOC) 4158
package PRIMARR2 PrimitiveArrayFunctions2 4162
PrimitiveArrayFunctions2 (PRIMARR2) 4163
package PRIMELT PrimitiveElement 4165
PrimitiveElement (PRIMELT) 4166
package ODEPRIM PrimitiveRatDE 4170
PrimitiveRatDE (ODEPRIM) 4171
package ODEPRRIC PrimitiveRatRicDE 4177
PrimitiveRatRicDE (ODEPRRIC) 4179
package PRINT PrintPackage 4188
PrintPackage (PRINT) 4189
package PSEUDLIN PseudoLinearNormalForm 4190
PseudoLinearNormalForm (PSEUDLIN) 4192
package PRS PseudoRemainderSequence 4199
PseudoRemainderSequence (PRS) 4200
package INTPAF PureAlgebraicIntegration 4232
PureAlgebraicIntegration (INTPAF) 4233
package ODEPAL PureAlgebraicLODE 4247
PureAlgebraicLODE (ODEPAL) 4248
package PUSHVAR PushVariables 4250
PushVariables (PUSHVAR) 4251

18 Chapter Q **4255**
package QALGSET2 QuasiAlgebraicSet2 4255
QuasiAlgebraicSet2 (QALGSET2) 4256
package QCMPACK QuasiComponentPackage 4260
QuasiComponentPackage (QCMPACK) 4261
package QFCAT2 QuotientFieldCategoryFunctions2 4275
QuotientFieldCategoryFunctions2 (QFCAT2) 4276

package QUATCT2 QuaternionCategoryFunctions2 4277
QuaternionCategoryFunctions2 (QUATCT2) 4279

19 Chapter R **4281**
package REP RadicalEigenPackage 4281
RadicalEigenPackage (REP) 4282
package SOLVERAD RadicalSolvePackage 4288
RadicalSolvePackage (SOLVERAD) 4301
package RADUTIL RadixUtilities 4311
RadixUtilities (RADUTIL) 4312
package RDIST RandomDistributions 4313
RandomDistributions (RDIST) 4314
package RFDIST RandomFloatDistributions 4317
RandomFloatDistributions (RFDIST) 4318
package RIDIST RandomIntegerDistributions 4322
RandomIntegerDistributions (RIDIST) 4323
package RANDSRC RandomNumberSource 4325
RandomNumberSource (RANDSRC) 4326
package RATFACT RationalFactorize 4328
RationalFactorize (RATFACT) 4329
package RF RationalFunction 4331
RationalFunction (RF) 4333
package DEFINTRF RationalFunctionDefiniteIntegration 4336
RationalFunctionDefiniteIntegration (DEFINTRF) 4337
package RFFACT RationalFunctionFactor 4340
RationalFunctionFactor (RFFACT) 4341
package RFFACTOR RationalFunctionFactorizer 4343
RationalFunctionFactorizer (RFFACTOR) 4344
package INTRF RationalFunctionIntegration 4346
RationalFunctionIntegration (INTRF) 4347
package LIMITRF RationalFunctionLimitPackage 4349
RationalFunctionLimitPackage (LIMITRF) 4350
package SIGNRF RationalFunctionSign 4356
RationalFunctionSign (SIGNRF) 4357
package SUMRF RationalFunctionSum 4360
RationalFunctionSum (SUMRF) 4366
package INTRAT RationalIntegration 4368
RationalIntegration (INTRAT) 4370
package RINTERP RationalInterpolation 4372
Introduction 4372
Questions and Outlook 4372
RationalInterpolation (RINTERP) 4373
package ODERAT RationalLODE 4376
RationalLODE (ODERAT) 4378
package RATRET RationalRetractions 4386
RationalRetractions (RATRET) 4387

package ODERTRIC RationalRicDE 4389
RationalRicDE (ODERTRIC) 4390
package RURPK RationalUnivariateRepresentationPackage 4400
RationalUnivariateRepresentationPackage (RURPK) 4401
package POLUTIL RealPolynomialUtilitiesPackage 4406
RealPolynomialUtilitiesPackage (POLUTIL) 4408
package REALSOLV RealSolvePackage 4411
RealSolvePackage (REALSOLV) 4415
package REAL0 RealZeroPackage 4417
RealZeroPackage (REAL0) 4418
package REAL0Q RealZeroPackageQ 4429
RealZeroPackageQ (REAL0Q) 4430
package RMCAT2 RectangularMatrixCategoryFunctions2 4433
RectangularMatrixCategoryFunctions2 (RMCAT2) 4434
package RECOP RecurrenceOperator 4436
RecurrenceOperator (RECOP) 4437
Defining new operators 4438
Recurrences 4440
Functional Equations 4443
package RDIV ReducedDivisor 4447
ReducedDivisor (RDIV) 4448
package ODERED ReduceLODE 4450
ReduceLODE (ODERED) 4451
package REDORDER ReductionOfOrder 4453
ReductionOfOrder (REDORDER) 4454
package RSDCMPK RegularSetDecompositionPackage 4457
RegularSetDecompositionPackage (RSDCMPK) 4459
The decompose algorithm 4459
package RSETGCD RegularTriangularSetGcdPackage 4470
RegularTriangularSetGcdPackage (RSETGCD) 4471
package REPDB RepeatedDoubling 4484
RepeatedDoubling (REPDB) 4485
package REPSQ RepeatedSquaring 4486
RepeatedSquaring (REPSQ) 4487
package REP1 RepresentationPackage1 4489
RepresentationPackage1 (REP1) 4491
package REP2 RepresentationPackage2 4501
RepresentationPackage2 (REP2) 4502
package RESLATC ResolveLatticeCompletion 4527
ResolveLatticeCompletion (RESLATC) 4528
package RETSOL RetractSolvePackage 4529
RetractSolvePackage (RETSOL) 4530
package RFP RootsFindingPackage 4533
RootsFindingPackage (RFP) 4534

20 Chapter S **4539**
package SAERFFC SAERationalFunctionAlgFactor 4539
SAERationalFunctionAlgFactor (SAERFFC) 4540
package FORMULA1 ScriptFormulaFormat1 4541
ScriptFormulaFormat1 (FORMULA1) 4542
package SEGBIND2 SegmentBindingFunctions2 4543
SegmentBindingFunctions2 (SEGBIND2) 4544
package SEG2 SegmentFunctions2 4545
SegmentFunctions2 (SEG2) 4546
package SAEFACT SimpleAlgebraicExtensionAlgFactor 4548
SimpleAlgebraicExtensionAlgFactor (SAEFACT) 4549
package SIMPAN SimplifyAlgebraicNumberConvertPackage 4550
SimplifyAlgebraicNumberConvertPackage (SIMPAN) 4552
package SMITH SmithNormalForm 4553
SmithNormalForm (SMITH) 4554
package SCACHE SortedCache 4562
SortedCache (SCACHE) 4563
package SORTPAK SortPackage 4566
SortPackage (SORTPAK) 4567
package SUP2 SparseUnivariatePolynomialFunctions2 4570
SparseUnivariatePolynomialFunctions2 (SUP2) 4571
package SPECOUT SpecialOutputPackage 4572
SpecialOutputPackage (SPECOUT) 4573
package SFQCMPK SquareFreeQuasiComponentPackage 4576
SquareFreeQuasiComponentPackage (SFQCMPK) 4578
package SRDCMPK SquareFreeRegularSetDecompositionPackage 4592
SquareFreeRegularSetDecompositionPackage (SRDCMPK) 4593
package SFRGCD SquareFreeRegularTriangularSetGcdPackage 4604
SquareFreeRegularTriangularSetGcdPackage (SFRGCD) 4605
package MATSTOR StorageEfficientMatrixOperations 4621
StorageEfficientMatrixOperations (MATSTOR) 4623
package STREAM1 StreamFunctions1 4629
StreamFunctions1 (STREAM1) 4630
package STREAM2 StreamFunctions2 4632
StreamFunctions2 (STREAM2) 4633
package STREAM3 StreamFunctions3 4635
StreamFunctions3 (STREAM3) 4636
package STINPROD StreamInfiniteProduct 4638
StreamInfiniteProduct (STINPROD) 4639
package STTAYLOR StreamTaylorSeriesOperations 4641
StreamTaylorSeriesOperations (STTAYLOR) 4643
package STNSR StreamTensor 4659
StreamTensor (STNSR) 4660
package STTF StreamTranscendentalFunctions 4661
StreamTranscendentalFunctions (STTF) 4662
package STTFNC StreamTranscendentalFunctionsNonCommutative 4678

StreamTranscendentalFunctionsNonCommutative (STTFNC) 4679
package SCPKG StructuralConstantsPackage 4688
StructuralConstantsPackage (SCPKG) 4689
package SHP SturmHabichtPackage 4694
SturmHabichtPackage (SHP) 4695
package SUBRESP SubResultantPackage 4707
SubResultantPackage (SUBRESP) 4708
package SUPFRACF SupFractionFactorizer 4713
SupFractionFactorizer (SUPFRACF) 4714
package ODESYS SystemODESolver 4716
SystemODESolver (ODESYS) 4718
package SYSSOLP SystemSolvePackage 4726
SystemSolvePackage (SYSSOLP) 4728
package SGCF SymmetricGroupCombinatoricFunctions 4736
SymmetricGroupCombinatoricFunctions (SGCF) 4737
package SYMFUNC SymmetricFunctions 4751
SymmetricFunctions (SYMFUNC) 4752

21 Chapter T **4755**
package TABLBUMP TableauxBumpers 4755
TableauxBumpers (TABLBUMP) 4756
package TBCMPPK TabulatedComputationPackage 4761
TabulatedComputationPackage (TBCMPPK) 4762
package TANEXP TangentExpansions 4767
TangentExpansions (TANEXP) 4768
package UTSSOL TaylorSolve 4770
TaylorSolve (UTSSOL) 4772
package TEMUTL TemplateUtilities 4775
TemplateUtilities (TEMUTL) 4776
package TEX1 TexFormat1 4778
TexFormat1 (TEX1) 4779
package TOOLSIGN ToolsForSign 4780
ToolsForSign (TOOLSIGN) 4781
package DRAW TopLevelDrawFunctions 4784
TopLevelDrawFunctions (DRAW) 4785
package DRAWCURV TopLevelDrawFunctionsForAlgebraicCurves 4796
TopLevelDrawFunctionsForAlgebraicCurves (DRAWCURV) 4797
package DRAWCFUN TopLevelDrawFunctionsForCompiledFunctions 4801
TopLevelDrawFunctionsForCompiledFunctions (DRAWCFUN) 4803
package DRAWPT TopLevelDrawFunctionsForPoints 4824
TopLevelDrawFunctionsForPoints (DRAWPT) 4825
package TOPSP TopLevelThreeSpace 4828
TopLevelThreeSpace (TOPSP) 4829
package INTHERTR TranscendentalHermiteIntegration 4830
TranscendentalHermiteIntegration (INTHERTR) 4831
package INTTR TranscendentalIntegration 4833

TranscendentalIntegration (INTTR) 4834
package TRMANIP TranscendentalManipulations 4851
TranscendentalManipulations (TRMANIP) 4852
The htrigs function 4860
package RDETR TranscendentalRischDE 4872
TranscendentalRischDE (RDETR) 4873
package RDETRS TranscendentalRischDESystem 4879
TranscendentalRischDESystem (RDETRS) 4880
package SOLVETRA TransSolvePackage 4888
TransSolvePackage (SOLVETRA) 4894
package SOLVESER TransSolvePackageService 4912
TransSolvePackageService (SOLVESER) 4913
package TRIMAT TriangularMatrixOperations 4917
TriangularMatrixOperations (TRIMAT) 4918
package TRIGMNIP TrigonometricManipulations 4920
TrigonometricManipulations (TRIGMNIP) 4922
package TUBETOOL TubePlotTools 4927
TubePlotTools (TUBETOOL) 4928
package CLIP TwoDimensionalPlotClipping 4932
TwoDimensionalPlotClipping (CLIP) 4934
package TWOFACT TwoFactorize 4944
TwoFactorize (TWOFACT) 4945

22 Chapter U **4955**
package UNIFACT UnivariateFactorize 4955
UnivariateFactorize (UNIFACT) 4956
package UFPS1 UnivariateFormalPowerSeriesFunctions 4967
UnivariateFormalPowerSeriesFunctions (UFPS1) 4968
package ULS2 UnivariateLaurentSeriesFunctions2 4969
UnivariateLaurentSeriesFunctions2 (ULS2) 4970
package UPOLYC2 UnivariatePolynomialCategoryFunctions2 4971
UnivariatePolynomialCategoryFunctions2 (UPOLYC2) 4972
package UPCDEN UnivariatePolynomialCommonDenominator 4974
UnivariatePolynomialCommonDenominator (UPCDEN) 4975
package UPDECOMP UnivariatePolynomialDecompositionPackage 4977
UnivariatePolynomialDecompositionPackage (UPDECOMP) 4978
package UPDIVP UnivariatePolynomialDivisionPackage 4982
UnivariatePolynomialDivisionPackage (UPDIVP) 4983
package UP2 UnivariatePolynomialFunctions2 4984
UnivariatePolynomialFunctions2 (UP2) 4985
package UPMP UnivariatePolynomialMultiplicationPackage 4987
UnivariatePolynomialMultiplicationPackage (UPMP) 4988
package UPSQFREE UnivariatePolynomialSquareFree 4991
UnivariatePolynomialSquareFree (UPSQFREE) 4993
package UPXS2 UnivariatePuiseuxSeriesFunctions2 4997
UnivariatePuiseuxSeriesFunctions2 (UPXS2) 4998

package OREPCTO UnivariateSkewPolynomialCategoryOps 5000
UnivariateSkewPolynomialCategoryOps (OREPCTO) 5001
package UTS2 UnivariateTaylorSeriesFunctions2 5006
UnivariateTaylorSeriesFunctions2 (UTS2) 5007
package UTSODE UnivariateTaylorSeriesODESolver 5008
UnivariateTaylorSeriesODESolver (UTSODE) 5009
package UNISEG2 UniversalSegmentFunctions2 5014
UniversalSegmentFunctions2 (UNISEG2) 5015
package UDPO UserDefinedPartialOrdering 5016
UserDefinedPartialOrdering (UDPO) 5017
package UDVO UserDefinedVariableOrdering 5021
UserDefinedVariableOrdering (UDVO) 5022
package UTSODETL UTSodetools 5024
UTSodetools (UTSODETL) 5025
package POLYVEC U32VectorPolynomialOperations 5027
U32VectorPolynomialOperations (POLYVEC) 5029

23 Chapter V **5049**
package VECTOR2 VectorFunctions2 5049
VectorFunctions2 (VECTOR2) 5050
package VIEWDEF ViewDefaultsPackage 5052
ViewDefaultsPackage (VIEWDEF) 5053
package VIEW ViewportPackage 5061
ViewportPackage (VIEW) 5062

24 Chapter W **5067**
package WEIER WeierstrassPreparation 5067
WeierstrassPreparation (WEIER) 5068
package WFFINTBS WildFunctionFieldIntegralBasis 5074
WildFunctionFieldIntegralBasis (WFFINTBS) 5075

25 Chapter X **5083**
package XEXPPKG XExponentialPackage 5083
XExponentialPackage (XEXPPKG) 5084

26 Chapter Y **5087**

27 Chapter Z **5089**
package ZDSOLVE ZeroDimensionalSolvePackage 5089
ZeroDimensionalSolvePackage (ZDSOLVE) 5148

28 Chunk collections **5165**

Bibliography **5187**

Index **5205**

Volume 10.5: Axiom Algebra: Numerics

1 Numerical Analysis **1**

2 The Quality of Computed Solutions by Sven Hammarling **3**
2.1 Introduction . . . 3
2.2 Floating Point Numbers and IEEE Arithmetic . . . 4
2.2.1 Example 2.1 (Floating point numbers) . . . 4
2.3 Why Worry about Computed Solutions? . . . 6
2.3.1 Example 3.1 (Cancellation) . . . 6
2.3.2 Example 3.2 (Sample variance [**?**],Section 1.9) . . . 7
2.3.3 Example 3.3 (Hypotenuse) . . . 8
2.3.4 Example 3.4 (Modulus of a complex number) . . . 9
2.3.5 Example 3.5 (Sample mean)[**?**] . . . 10
2.4 Condition, Stability and Error Analysis . . . 10
2.4.1 Condition . . . 10
subsubsection.2.4.1.1 subsubsection.2.4.1.2 subsubsection.2.4.1.3 subsubsection.2.4.1.4 subsubsection.2.4.1.5 subsubsection.2.4.1.6 subsubsection.2.4.1.7 subsubsection.2.4.1.8
2.4.2 Stability . . . 16
subsubsection.2.4.2.1 subsubsection.2.4.2.2 subsubsection.2.4.2.3 subsubsection.2.4.2.4 subsubsection.2.4.2.5
2.4.3 Error Analysis . . . 21
subsubsection.2.4.3.1 subsubsection.2.4.3.2 subsubsection.2.4.3.3 subsubsection.2.4.3.4
2.5 Floating Point Error Analysis . . . 24
2.5.1 Example 5.1 (Floating point numbers) . . . 25
2.5.2 Example 5.2 (Product of values) . . . 26
2.5.3 Example 5.3 (Sum of values) . . . 26
2.5.4 Example 5.4 (Difference of two squares) . . . 27
2.5.5 Example 5.5 (The need for pivoting) . . . 28
2.6 Posing the Mathematical Problem . . . 31
2.7 Error Bounds and Software . . . 31
2.8 Other Approaches . . . 35
2.8.1 Example 8.1 (Cancellation and interval arithmetic) . . . 35
2.9 Summary . . . 35

3 Chapter Overview **37**

4 Optimizations **39**

5 Algebra Cover Code **41**
5.1 package BLAS1 BlasLevelOne . . . 41
5.1.1 Axiom Package unit tests . . . 41
5.1.2 Axiom help page . . . 73
5.1.3 BlasLevelOne (BLAS1 Spad code) . . . 74
5.2 lsame . . . 79
5.2.1 fortran code . . . 80

5.2.2 lisp code . . . 81
5.3 xerbla . . . 82
5.3.1 fortran code . . . 82
5.3.2 lisp code . . . 83

6 BLAS Level 1 Real Vector Operations 85
6.1 sasum - the sum of the absolute values . . . 85
6.1.1 Axiom unit tests . . . 85
6.1.2 Axiom help page . . . 85
6.1.3 fortran code . . . 86
6.1.4 lisp code . . . 87
6.2 saxpy - constant times a vector plus a vector . . . 88
6.2.1 Axiom unit tests . . . 88
6.2.2 Axiom help page . . . 89
6.2.3 fortran code . . . 89
6.2.4 lisp code . . . 91
6.3 scabs1 - abs(real(z))+abs(imag(z)) of a complex number . . . 92
6.3.1 Axiom unit tests . . . 92
6.3.2 Axiom help page . . . 93
6.3.3 fortran code . . . 93
6.3.4 lisp code . . . 94
6.4 scasum - abs(real(z))+abs(imag(z)) of a complex vector . . . 94
6.4.1 Axiom unit tests . . . 94
6.4.2 Axiom help page . . . 95
6.4.3 fortran code . . . 95
6.4.4 lisp code . . . 96
6.5 scnrm2 - Euclidean norm of a vector . . . 97
6.5.1 Axiom unit tests . . . 97
6.5.2 Axiom help page . . . 97
6.5.3 fortran code . . . 98
6.5.4 lisp code . . . 99
6.6 scopy - copy a vector x to a vector y . . . 101
6.6.1 Axiom unit tests . . . 101
6.6.2 Axiom help page . . . 101
6.6.3 fortran code . . . 101
6.6.4 lisp code . . . 103
6.7 sdot - compute the dot product of two vectors . . . 104
6.7.1 Axiom unit tests . . . 104
6.7.2 Axiom help page . . . 105
6.7.3 fortran code . . . 105
6.7.4 lisp code . . . 107
6.8 sdsdot - compute the inner product of two vectors . . . 108
6.8.1 Axiom unit tests . . . 108
6.8.2 Axiom help page . . . 109
6.8.3 fortran code . . . 109
6.8.4 lisp code . . . 111

6.9 snrm2 - Euclidean norm of a vector $\sqrt{x'x}$ . . . 113
6.9.1 Axiom unit tests . . . 113
6.9.2 Axiom help page . . . 113
6.9.3 fortran code . . . 114
6.9.4 lisp code . . . 115
6.10 srot - applies a plane rotation . . . 116
6.10.1 Axiom unit tests . . . 116
6.10.2 Axiom help page . . . 116
6.10.3 fortran code . . . 117
6.10.4 lisp code . . . 118
6.11 srotg - construct givens plane rotation . . . 119
6.11.1 Axiom unit tests . . . 119
6.11.2 Axiom help page . . . 119
6.11.3 fortran code . . . 120
6.11.4 lisp code . . . 121
6.12 srotm - apply a modified givens transformation . . . 121
6.12.1 Axiom unit tests . . . 121
6.12.2 Axiom help page . . . 122
6.12.3 fortran code . . . 123
6.12.4 lisp code . . . 125
6.13 srotmg - apply a modified givens transformation . . . 128
6.13.1 Axiom unit tests . . . 128
6.13.2 Axiom help page . . . 128
6.13.3 fortran code . . . 130
6.13.4 lisp code . . . 133
6.14 sscal - scales a vector by a constant . . . 135
6.14.1 Axiom unit tests . . . 135
6.14.2 Axiom help page . . . 135
6.14.3 fortran code . . . 136
6.14.4 lisp code . . . 137
6.15 sswap - interchange two vectors . . . 138
6.15.1 Axiom unit tests . . . 138
6.15.2 Axiom help page . . . 138
6.15.3 fortran code . . . 139
6.15.4 lisp code . . . 140

7 BLAS Level 1 Double Vector Operations 143
7.1 dasum - sum of the absolute values . . . 143
7.1.1 Axiom unit tests . . . 143
7.1.2 Axiom help page . . . 147
7.1.3 fortran code . . . 151
7.1.4 fortran unit test . . . 152
7.1.5 lisp code . . . 155
7.2 daxpy - constant time vector plus a vector . . . 155
7.2.1 Axiom unit tests . . . 155
7.2.2 Axiom help page . . . 159

7.2.3 fortran code . . . 162
7.2.4 fortran unit test . . . 163
7.2.5 lisp code . . . 165
7.3 dcabs1 - abs(real(z))+abs(imag(z)) . . . 167
7.3.1 Axiom unit tests . . . 167
7.3.2 Axiom help page . . . 169
7.3.3 fortran code . . . 170
7.3.4 fortran unit test . . . 170
7.3.5 lisp code . . . 171
7.4 dcopy - copy a vector x to a vector y . . . 172
7.4.1 Axiom unit tests . . . 172
7.4.2 Axiom help page . . . 175
7.4.3 fortran code . . . 177
7.4.4 fortran unit test . . . 179
7.4.5 lisp code . . . 180
7.5 ddot - dot product of two vectors . . . 182
7.5.1 Axiom unit tests . . . 182
7.5.2 Axiom help page . . . 183
7.5.3 fortran code . . . 185
7.5.4 fortran unit test . . . 187
7.5.5 lisp code . . . 188
7.6 dnrm2 - Euclidean norm of a vector . . . 189
7.6.1 Axiom unit tests . . . 189
7.6.2 Axiom help page . . . 190
7.6.3 fortran code . . . 191
7.6.4 fortran unit test . . . 193
7.6.5 lisp code . . . 193
7.7 drot - applies a plane rotation . . . 195
7.7.1 Axiom unit tests . . . 195
7.7.2 Axiom help page . . . 199
7.7.3 fortran code . . . 202
7.7.4 fortran unit test . . . 203
7.7.5 lisp code . . . 207
7.8 drotg - constructs givens plane rotation . . . 210
7.8.1 Axiom unit tests . . . 210
7.8.2 Axiom help page . . . 212
7.8.3 fortran code . . . 216
7.8.4 fortran unit test . . . 216
7.8.5 lisp code . . . 220
7.9 drotm - Apply the modified givens transformation to DX^T . . . 222
7.9.1 Axiom unit tests . . . 222
7.9.2 Axiom help page . . . 222
7.9.3 fortran code . . . 224
7.9.4 lisp code . . . 226
7.10 drotmg - Construct the modified givens transformation matrix . . . 229
7.10.1 Axiom unit tests . . . 229

7.10.2 Axiom help page . . . 229
7.10.3 fortran code . . . 230
7.10.4 lisp code . . . 233
7.11 dscal - scale a vector by a constant . . . 235
7.11.1 Axiom unit tests . . . 235
7.11.2 Axiom help page . . . 236
7.11.3 fortran code . . . 239
7.11.4 fortran unit test . . . 240
7.11.5 lisp code . . . 241
7.12 dsdot - compute the inner product of two vectors . . . 242
7.12.1 Axiom unit tests . . . 243
7.12.2 Axiom help page . . . 243
7.12.3 fortran code . . . 244
7.12.4 lisp code . . . 245
7.13 dswap - interchanges two vectors . . . 246
7.13.1 Axiom unit tests . . . 246
7.13.2 Axiom help page . . . 248
7.13.3 fortran code . . . 250
7.13.4 fortran unit test . . . 251
7.13.5 lisp code . . . 253
7.14 dtrsv - solve $Ax = b$ or $A^T x = b$ . . . 254
7.14.1 Axiom unit tests . . . 254
7.14.2 Axiom help page . . . 254
7.14.3 fortran code . . . 256
7.14.4 lisp code . . . 260
7.15 dzasum - sum of the dcabs1 of a complex vector . . . 266
7.15.1 Axiom unit tests . . . 266
7.15.2 Axiom help page . . . 267
7.15.3 fortran code . . . 269
7.15.4 fortran unit test . . . 270
7.15.5 lisp code . . . 271
7.16 dznrm2 - Euclidean norm of a vector $= \sqrt{x^H * x}$ . . . 272
7.16.1 Axiom unit tests . . . 272
7.16.2 Axiom help page . . . 273
7.16.3 fortran code . . . 275
7.16.4 fortran unit test . . . 276
7.16.5 lisp code . . . 278
7.17 icamax - maximum index function . . . 279
7.17.1 Axiom unit tests . . . 279
7.17.2 Axiom help page . . . 281
7.17.3 fortran code . . . 283
7.17.4 fortran unit test . . . 284
7.17.5 lisp code . . . 286
7.18 idamax - index of element having max. absolute value . . . 287
7.18.1 Axiom unit tests . . . 287
7.18.2 Axiom help page . . . 289

7.18.3 fortran code . . . 291
7.18.4 fortran unit test . . . 293
7.18.5 lisp code . . . 294
7.19 isamax - index of element having max. absolute value . . . 295
7.19.1 Axiom unit tests . . . 295
7.19.2 Axiom help page . . . 297
7.19.3 fortran code . . . 299
7.19.4 fortran unit test . . . 300
7.19.5 lisp code . . . 302
7.20 izamax . . . 303
7.20.1 Axiom unit tests . . . 303
7.20.2 Axiom help page . . . 304
7.20.3 fortran code . . . 306
7.20.4 fortran unit test . . . 307
7.20.5 lisp code . . . 309

8 BLAS Level 1 Complex Vector Operations 311
8.1 caxpy - constant times a vector plus a vector . . . 311
8.1.1 Axiom unit tests . . . 311
8.1.2 Axiom help page . . . 311
8.1.3 fortran code . . . 312
8.1.4 lisp code . . . 313
8.2 ccopy - copies a vector x to a vector y . . . 314
8.2.1 Axiom unit tests . . . 314
8.2.2 Axiom help page . . . 314
8.2.3 fortran code . . . 315
8.2.4 lisp code . . . 316
8.3 cdotc - dot product of two complex vectors $X^H Y$ . . . 317
8.3.1 Axiom unit tests . . . 317
8.3.2 Axiom help page . . . 317
8.3.3 fortran code . . . 318
8.3.4 lisp code . . . 319
8.4 cdotu - dot product of two complex vectors $X^T Y$ . . . 320
8.4.1 Axiom unit tests . . . 320
8.4.2 Axiom help page . . . 320
8.4.3 fortran code . . . 321
8.4.4 lisp code . . . 322
8.5 crotg - determines a complex Givens rotation . . . 323
8.5.1 Axiom unit tests . . . 323
8.5.2 Axiom help page . . . 323
8.5.3 fortran code . . . 324
8.5.4 lisp code . . . 325
8.6 cscal - scales a vector by a constant . . . 325
8.6.1 Axiom unit tests . . . 325
8.6.2 Axiom help page . . . 326
8.6.3 fortran code . . . 326

8.6.4 lisp code . . . 327
8.7 csrot - appies a plane rotation . . . 328
8.7.1 Axiom unit tests . . . 328
8.7.2 Axiom help page . . . 328
8.7.3 fortran code . . . 329
8.7.4 lisp code . . . 331
8.8 csscal - scales a complex vector by a real constant . . . 332
8.8.1 Axiom unit tests . . . 332
8.8.2 Axiom help page . . . 332
8.8.3 fortran code . . . 333
8.8.4 lisp code . . . 334
8.9 cswap - interchanges two vectors . . . 335
8.9.1 Axiom unit tests . . . 335
8.9.2 Axiom help page . . . 335
8.9.3 fortran code . . . 336
8.9.4 lisp code . . . 337

9 BLAS Level 1 Complex16 Vector Operations 339
9.1 zaxpy - constant times a vector plus a vector . . . 339
9.1.1 Axiom unit tests . . . 339
9.1.2 Axiom help page . . . 343
9.1.3 fortran code . . . 345
9.1.4 fortran unit test . . . 346
9.1.5 lisp code . . . 352
9.2 zcopy - copies a vector x to a vector y . . . 354
9.2.1 Axiom unit tests . . . 354
9.2.2 Axiom help page . . . 354
9.2.3 fortran code . . . 356
9.2.4 lisp code . . . 357
9.3 zdotc - dot product of two complex vectors $X^H Y$ . . . 358
9.3.1 Axiom unit tests . . . 358
9.3.2 Axiom help page . . . 358
9.3.3 fortran code . . . 359
9.3.4 lisp code . . . 360
9.4 zdotu - forms the dot product of two complex vectors $X^T Y$ . . . 362
9.4.1 Axiom unit tests . . . 362
9.4.2 Axiom help page . . . 362
9.4.3 fortran code . . . 363
9.4.4 lisp code . . . 364
9.5 zdrot - applies a plane rotation . . . 366
9.5.1 Axiom unit tests . . . 366
9.5.2 Axiom help page . . . 366
9.5.3 fortran code . . . 367
9.5.4 lisp code . . . 368
9.6 zdscal - scales a vector by a constant . . . 370
9.6.1 Axiom unit tests . . . 370

9.6.2 Axiom help page . . . 370
9.6.3 fortran code . . . 371
9.6.4 lisp code . . . 372
9.7 zrotg - determines a double complex Givens rotation . . . 373
9.7.1 Axiom unit tests . . . 373
9.7.2 Axiom help page . . . 373
9.7.3 fortran code . . . 375
9.7.4 lisp code . . . 376
9.8 zscal - scales a vector by a constant . . . 377
9.8.1 Axiom unit tests . . . 377
9.8.2 Axiom help page . . . 377
9.8.3 fortran code . . . 378
9.8.4 lisp code . . . 379
9.9 zswap - interchanges two vectors . . . 380
9.9.1 Axiom unit tests . . . 380
9.9.2 Axiom help page . . . 380
9.9.3 fortran code . . . 381
9.9.4 lisp code . . . 382

10 BLAS Level 2 Real Matrix-Vector Operations 385
10.1 sgbmv - $\alpha Ax + \beta y$ or $\alpha A^T x + \beta y$ . . . 385
10.1.1 Axiom unit tests . . . 385
10.1.2 Axiom help page . . . 385
10.1.3 fortran code . . . 388
10.1.4 lisp code . . . 391
10.2 sgemv - matrix-vector $\alpha Ax + \beta y$ or $\alpha A^T x + \beta y$ . . . 396
10.2.1 Axiom unit tests . . . 396
10.2.2 Axiom help page . . . 396
10.2.3 fortran code . . . 398
10.2.4 lisp code . . . 402
10.3 sger - rank 1 $\alpha xy^T + A$ . . . 405
10.3.1 Axiom unit tests . . . 405
10.3.2 Axiom help page . . . 405
10.3.3 fortran code . . . 407
10.3.4 lisp code . . . 409
10.4 ssbmv - $\alpha Ax + \beta y$ . . . 411
10.4.1 Axiom unit tests . . . 411
10.4.2 Axiom help page . . . 411
10.4.3 fortran code . . . 414
10.4.4 lisp code . . . 417
10.5 sspmv - matrix-vector $\alpha Ax + \beta y$ . . . 423
10.5.1 Axiom unit tests . . . 423
10.5.2 Axiom help page . . . 423
10.5.3 fortran code . . . 425
10.5.4 lisp code . . . 428
10.6 sspr - rank 1 $\alpha xx^T + A$ . . . 433

10.6.1 Axiom unit tests . . . 433
10.6.2 Axiom help page . . . 434
10.6.3 fortran code . . . 435
10.6.4 lisp code . . . 438
10.7 sspr2 - rank 2 $\alpha xy^T + \alpha yx^T + A$ . . . 441
10.7.1 Axiom unit tests . . . 441
10.7.2 Axiom help page . . . 441
10.7.3 fortran code . . . 443
10.7.4 lisp code . . . 446
10.8 ssymv - matrix-vector $\alpha Ax + \beta y$ . . . 450
10.8.1 Axiom unit tests . . . 450
10.8.2 Axiom help page . . . 450
10.8.3 fortran code . . . 452
10.8.4 lisp code . . . 456
10.9 ssyr - symmetric rank 1 $\alpha xx^T + A$ . . . 460
10.9.1 Axiom unit tests . . . 460
10.9.2 Axiom help page . . . 461
10.9.3 fortran code . . . 462
10.9.4 lisp code . . . 465
10.10 ssyr2 - $\alpha xy^T + \alpha yx^T + A$ . . . 468
10.10.1 Axiom unit tests . . . 468
10.10.2 Axiom help page . . . 468
10.10.3 fortran code . . . 470
10.10.4 lisp code . . . 473
10.11 stbmv - banded matrix-vector $x = A * x$ or $x = A^T x$ . . . 476
10.11.1 Axiom unit tests . . . 476
10.11.2 Axiom help page . . . 477
10.11.3 fortran code . . . 479
10.11.4 lisp code . . . 483
10.12 stbsv - banded solve system of equations $Ax = b$ or $A^T x = b$ . . . 490
10.12.1 Axiom unit tests . . . 490
10.12.2 Axiom help page . . . 491
10.12.3 fortran code . . . 493
10.12.4 lisp code . . . 497
10.13 stpmv - matrix-vector $x = A * x$ or $x = A^T x$ . . . 504
10.13.1 Axiom unit tests . . . 504
10.13.2 Axiom help page . . . 504
10.13.3 fortran code . . . 506
10.13.4 lisp code . . . 510
10.14 stpsv - solve systems of equations $Ax = b$ or $A^T x = b$ . . . 517
10.14.1 Axiom unit tests . . . 517
10.14.2 Axiom help page . . . 517
10.14.3 fortran code . . . 519
10.14.4 lisp code . . . 523
10.15 strmv - matrix-vector $x = Ax$ or $x = A^T x$ . . . 530
10.15.1 Axiom unit tests . . . 530

10.15.2 Axiom help page . . . 530
10.15.3 fortran code . . . 532
10.15.4 lisp code . . . 536
10.16 strsv - solve systems of equations $Ax = b$ or $A^T x = b$ . . . 541
10.16.1 Axiom unit tests . . . 541
10.16.2 Axiom help page . . . 542
10.16.3 fortran code . . . 544
10.16.4 lisp code . . . 548

11 BLAS Level 2 Double Matrix-Vector Operations 555
11.1 dgbmv - band matrix $\alpha Ax + \beta y$ or $\alpha A^T x + \beta y$ . . . 555
11.1.1 Axiom unit tests . . . 555
11.1.2 Axiom help page . . . 555
11.1.3 fortran code . . . 558
11.1.4 lisp code . . . 561
11.2 dgemv - $\alpha Ax + \beta y$ or $\alpha A^T x + \beta y$ . . . 567
11.2.1 Axiom unit tests . . . 567
11.2.2 Axiom help page . . . 567
11.2.3 fortran code . . . 569
11.2.4 lisp code . . . 572
11.3 dger - rank 1 $\alpha xy^T + a$ . . . 577
11.3.1 Axiom unit tests . . . 577
11.3.2 Axiom help page . . . 577
11.3.3 fortran code . . . 578
11.3.4 lisp code . . . 580
11.4 dsbmv - banded $\alpha Ax + \beta y$ . . . 583
11.4.1 Axiom unit tests . . . 583
11.4.2 Axiom help page . . . 583
11.4.3 fortran code . . . 585
11.4.4 lisp code . . . 589
11.5 dspmv - matrix-vector operation $\alpha Ax + \beta y$ . . . 595
11.5.1 Axiom unit tests . . . 595
11.5.2 Axiom help page . . . 595
11.5.3 fortran code . . . 597
11.5.4 lisp code . . . 601
11.6 dspr - symmetric rank 1 $\alpha xx^T + A$ . . . 607
11.6.1 Axiom unit tests . . . 607
11.6.2 Axiom help page . . . 607
11.6.3 fortran code . . . 609
11.6.4 lisp code . . . 611
11.7 dspr2 - symmetric rank 2 $\alpha xy^T + \alpha yx^T + A$ . . . 615
11.7.1 Axiom unit tests . . . 615
11.7.2 Axiom help page . . . 615
11.7.3 fortran code . . . 617
11.7.4 lisp code . . . 620
11.8 dsymv - matrix-vector operation $\alpha Ax + \beta y$ . . . 625

11.8.1 Axiom unit tests . . . 625
11.8.2 Axiom help page . . . 626
11.8.3 fortran code . . . 628
11.8.4 lisp code . . . 631
11.9 dsyr - rank 1 $\alpha x x^T + A$ . . . 637
11.9.1 Axiom unit tests . . . 637
11.9.2 Axiom help page . . . 637
11.9.3 fortran code . . . 639
11.9.4 lisp code . . . 641
11.10 dsyr2 - symmetric rank 2 $\alpha x y^T + \alpha y x^T + A$ . . . 645
11.10.1 Axiom unit tests . . . 645
11.10.2 Axiom help page . . . 645
11.10.3 fortran code . . . 647
11.10.4 lisp code . . . 650
11.11 dtbmv - triangular banded matrix $x = Ax$ or $x = A^T x$ . . . 655
11.11.1 Axiom unit tests . . . 655
11.11.2 Axiom help page . . . 655
11.11.3 fortran code . . . 657
11.11.4 lisp code . . . 662
11.12 dtbsv - triangular banded matrix $Ax = b$ or $A^T x = b$ . . . 670
11.12.1 Axiom unit tests . . . 670
11.12.2 Axiom help page . . . 670
11.12.3 fortran code . . . 673
11.12.4 lisp code . . . 677
11.13 dtpmv - matrix-vector $x = Ax$ or $x = A^T x$ . . . 686
11.13.1 Axiom unit tests . . . 686
11.13.2 Axiom help page . . . 686
11.13.3 fortran code . . . 688
11.13.4 lisp code . . . 692
11.14 dtpsv - solve systems of equations $Ax = b$ or $A^T x = b$ . . . 700
11.14.1 Axiom unit tests . . . 700
11.14.2 Axiom help page . . . 701
11.14.3 fortran code . . . 703
11.14.4 lisp code . . . 707
11.15 dtrmv - matrix-vector $x = Ax$ or $x = A^T x$ . . . 715
11.15.1 Axiom unit tests . . . 715
11.15.2 Axiom help page . . . 715
11.15.3 fortran code . . . 717
11.15.4 lisp code . . . 721
11.16 dtrsv - solve system of equations $Ax = b$ or $A^{'} = b$ . . . 728
11.16.1 Axiom unit tests . . . 728
11.16.2 Axiom help page . . . 729
11.16.3 fortran code . . . 731
11.16.4 lisp code . . . 735

12 BLAS Level 2 Complex Matrix-Vector Operations 743
12.1 cgbmv - band mat-vec $\alpha Ax + \beta y$ or $\alpha A^T + \beta y$ or $\alpha A^H x + \beta y$ 743
12.1.1 Axiom unit tests 743
12.1.2 Axiom help page 743
12.1.3 fortran code 746
12.1.4 lisp code 750
12.2 cgemv - matrix-vector $\alpha Ax + \beta y$ or $\alpha A^T + \beta y$ or $\alpha A^H x + \beta y$ 756
12.2.1 Axiom unit tests 756
12.2.2 Axiom help page 756
12.2.3 fortran code 758
12.2.4 lisp code 762
12.3 cgerc - rank 1 $\alpha xy^H + A$ 767
12.3.1 Axiom unit tests 767
12.3.2 Axiom help page 767
12.3.3 fortran code 769
12.3.4 lisp code 771
12.4 cgeru - rank 1 $\alpha xy^T + A$ 773
12.4.1 Axiom unit tests 773
12.4.2 Axiom help page 773
12.4.3 fortran code 774
12.4.4 lisp code 776
12.5 chbmv - hermitian band matrix-vector $\alpha Ax + \beta y$ 778
12.5.1 Axiom unit tests 778
12.5.2 Axiom help page 779
12.5.3 fortran code 781
12.5.4 lisp code 785
12.6 chemv - hermitian matrix-vector $\alpha Ax + \beta y$ 791
12.6.1 Axiom unit tests 791
12.6.2 Axiom help page 791
12.6.3 fortran code 793
12.6.4 lisp code 796
12.7 cher - hermitian rank 1 $\alpha xx^H + A$ 801
12.7.1 Axiom unit tests 801
12.7.2 Axiom help page 802
12.7.3 fortran code 803
12.7.4 lisp code 806
12.8 cher2 - hermitian rank 2 $\alpha xy^H + conjg(\alpha)yx^H + A$ 811
12.8.1 Axiom unit tests 811
12.8.2 Axiom help page 811
12.8.3 fortran code 813
12.8.4 lisp code 817
12.9 chpmv - hermitian matrix-vector $\alpha Ax + \beta y$ 823
12.9.1 Axiom unit tests 823
12.9.2 Axiom help page 823
12.9.3 fortran code 825
12.9.4 lisp code 829

12.10chpr - hermitian $\alpha x x^H + A$ . . . 834
12.10.1 Axiom unit tests . . . 834
12.10.2 Axiom help page . . . 834
12.10.3 fortran code . . . 836
12.10.4 lisp code . . . 839
12.11chpr2 - hermitian rank 2 $\alpha x y^H + conjg(\alpha) y x^H + A$ . . . 844
12.11.1 Axiom unit tests . . . 844
12.11.2 Axiom help page . . . 845
12.11.3 fortran code . . . 846
12.11.4 lisp code . . . 850
12.12ctbmv - banded matrix-vector Ax or $A^T x$ or $A^H x$ . . . 856
12.12.1 Axiom unit tests . . . 856
12.12.2 Axiom help page . . . 857
12.12.3 fortran code . . . 859
12.12.4 lisp code . . . 864
12.13ctbsv - banded solved systems of equations $Ax = b$ or $A^T x = b$ or $A^H x = b$ . . . 874
12.13.1 Axiom unit tests . . . 874
12.13.2 Axiom help page . . . 875
12.13.3 fortran code . . . 877
12.13.4 lisp code . . . 882
12.14ctpmv - packed matrix-vector Ax or $A^T x$ or $A^H x$ . . . 892
12.14.1 Axiom unit tests . . . 892
12.14.2 Axiom help page . . . 893
12.14.3 fortran code . . . 895
12.14.4 lisp code . . . 899
12.15ctpsv - solve system of equations $Ax = b$ or $A^T x = b$ or $A^H x = b$ . . . 909
12.15.1 Axiom unit tests . . . 909
12.15.2 Axiom help page . . . 909
12.15.3 fortran code . . . 911
12.15.4 lisp code . . . 916
12.16ctrmv - matrix-vector Ax or $A^T x$ or $A^H x$ . . . 926
12.16.1 Axiom unit tests . . . 926
12.16.2 Axiom help page . . . 926
12.16.3 fortran code . . . 928
12.16.4 lisp code . . . 932
12.17ctrsv - solve systems of equations $Ax = b$ or $A^T x = b$ or $A^H x = b$ . . . 941
12.17.1 Axiom unit tests . . . 941
12.17.2 Axiom help page . . . 942
12.17.3 fortran code . . . 944
12.17.4 lisp code . . . 948

13 BLAS Level 2 Complex16 Matrix-Vector Operations 959
13.1 zgbmv - banded $\alpha Ax + \beta y$ or $\alpha A^T x + \beta y$ or $\alpha A^H x + \beta y$ . . . 959
13.1.1 Axiom unit tests . . . 959
13.1.2 Axiom help page . . . 959
13.1.3 fortran code . . . 962

13.1.4 lisp code 966
13.2 zgemv - matrix-vector $\alpha Ax + \beta y$ or $\alpha A^T x + \beta y$ or $\alpha A^H x + \beta y$ 972
13.2.1 Axiom unit tests 972
13.2.2 Axiom help page 972
13.2.3 fortran code 974
13.2.4 lisp code 978
13.3 zgerc - rank 1 $\alpha xy^H + A$ 983
13.3.1 Axiom unit tests 983
13.3.2 Axiom help page 983
13.3.3 fortran code 985
13.3.4 lisp code 987
13.4 zgeru - rank 1 $\alpha xy^T + A$ 989
13.4.1 Axiom unit tests 989
13.4.2 Axiom help page 990
13.4.3 fortran code 991
13.4.4 lisp code 993
13.5 zhbmv - hermitian band matrix-vector $\alpha Ax + \beta y$ 995
13.5.1 Axiom unit tests 995
13.5.2 Axiom help page 996
13.5.3 fortran code 998
13.5.4 lisp code 1002
13.6 zhemv - hermitian matrix-vector $\alpha Ax + \beta y$ 1008
13.6.1 Axiom unit tests 1008
13.6.2 Axiom help page 1008
13.6.3 fortran code 1010
13.6.4 lisp code 1014
13.7 zher - hermitian rank 1 $\alpha xx^H + A$ 1019
13.7.1 Axiom unit tests 1019
13.7.2 Axiom help page 1020
13.7.3 fortran code 1021
13.7.4 lisp code 1024
13.8 zher2 - hermitian rank 2 $\alpha xy^H + conjg(\alpha)yx^H + A$ 1030
13.8.1 Axiom unit tests 1030
13.8.2 Axiom help page 1031
13.8.3 fortran code 1032
13.8.4 lisp code 1036
13.9 zhpmv - hermitian matrix-vector $\alpha Ax + \beta y$ 1044
13.9.1 Axiom unit tests 1044
13.9.2 Axiom help page 1044
13.9.3 fortran code 1046
13.9.4 lisp code 1050
13.10 zhpr - hermitian rank 1 $\alpha xx^H + A$ 1056
13.10.1 Axiom unit tests 1056
13.10.2 Axiom help page 1056
13.10.3 fortran code 1058
13.10.4 lisp code 1061

13.11zhpr2 - hermitian rank 2 $\alpha xy^H + conjg(\alpha)yx^H + A$ . . . 1067
13.11.1 Axiom unit tests . . . 1067
13.11.2 Axiom help page . . . 1067
13.11.3 fortran code . . . 1069
13.11.4 lisp code . . . 1073
13.12ztbmv - band matrix-vector Ax or A^Tx or A^Hx . . . 1081
13.12.1 Axiom unit tests . . . 1081
13.12.2 Axiom help page . . . 1081
13.12.3 fortran code . . . 1084
13.12.4 lisp code . . . 1089
13.13ztbsv - solve equations $Ax = b$ or $A^Tx = b$ or $A^Hx = b$ . . . 1100
13.13.1 Axiom unit tests . . . 1100
13.13.2 Axiom help page . . . 1100
13.13.3 fortran code . . . 1103
13.13.4 lisp code . . . 1108
13.14ztpmv - matrix-vector Ax or A^Tx or A^Hx . . . 1119
13.14.1 Axiom unit tests . . . 1119
13.14.2 Axiom help page . . . 1119
13.14.3 fortran code . . . 1121
13.14.4 lisp code . . . 1126
13.15ztpsv - solves systems of equations $Ax = b$ or $A^Tx = b$ or $A^Hx = b$ . . . 1137
13.15.1 Axiom unit tests . . . 1137
13.15.2 Axiom help page . . . 1137
13.15.3 fortran code . . . 1139
13.15.4 lisp code . . . 1144
13.16ztrmv - triangular matrix-vector Ax or A^Tx or A^Hx . . . 1155
13.16.1 Axiom unit tests . . . 1155
13.16.2 Axiom help page . . . 1155
13.16.3 fortran code . . . 1157
13.16.4 lisp code . . . 1162
13.17ztrsv - triangular solve system of equations $Ax = b$ or $A^Tx = b$ or $A^Hx = b$ . . . 1171
13.17.1 Axiom unit tests . . . 1171
13.17.2 Axiom help page . . . 1171
13.17.3 fortran code . . . 1173
13.17.4 lisp code . . . 1178

14 BLAS Level 3 Real Matrix-Matrix Operations 1189
14.1 sgemm - $\alpha op(A)op(B) + \beta C$, $op(X) = X$ or $op(X) = X^T$ . . . 1189
14.1.1 Axiom unit tests . . . 1189
14.1.2 Axiom help page . . . 1189
14.1.3 fortran code . . . 1192
14.1.4 lisp code . . . 1196
14.2 ssymm - matrix-matrix $\alpha AB + \beta C$ or $\alpha BA + \beta C$ . . . 1200
14.2.1 Axiom unit tests . . . 1200
14.2.2 Axiom help page . . . 1201
14.2.3 fortran code . . . 1203

14.2.4 lisp code 1207
14.3 ssyr2k - rank2k $\alpha AB^T + \alpha BA^T + \beta C$ or $\alpha A^T B + \alpha B^T A + \beta C$ 1212
14.3.1 Axiom unit tests 1212
14.3.2 Axiom help page 1213
14.3.3 fortran code 1215
14.3.4 lisp code 1219
14.4 ssyrk - symmetric rank k $\alpha AA^T + \beta C$ or $\alpha A^T A + \beta C$ 1225
14.4.1 Axiom unit tests 1225
14.4.2 Axiom help page 1226
14.4.3 fortran code 1228
14.4.4 lisp code 1232
14.5 strmm - $\alpha op(A)B$ or $\alpha Bop(A)$, $op(A) = A$ or $op(A) = A^T$ 1237
14.5.1 Axiom unit tests 1237
14.5.2 Axiom help page 1237
14.5.3 fortran code 1240
14.5.4 lisp code 1244
14.6 strsm - $op(A)X = \alpha B$ or $Xop(A) = \alpha B$, $op(A) = A$ or $op(A) = A^T$ 1252
14.6.1 Axiom unit tests 1252
14.6.2 Axiom help page 1253
14.6.3 fortran code 1255
14.6.4 lisp code 1260

15 BLAS Level 3 Double Matrix-Matrix Operations 1271
15.1 dgemm - $\alpha op(A)op(B) + \beta C$, $op(X) = X$ or $op(X) = X^T$ 1271
15.1.1 Axiom unit tests 1271
15.1.2 Axiom help page 1271
15.1.3 fortran code 1274
15.1.4 lisp code 1278
15.2 dsymm - $\alpha AB + \beta C$ or $\alpha BA + \beta C$ 1283
15.2.1 Axiom unit tests 1283
15.2.2 Axiom help page 1284
15.2.3 fortran code 1286
15.2.4 lisp code 1290
15.3 dsyr2k - $\alpha AB^T + \alpha BA^T + \beta C$ or $\alpha A^T B + \alpha B^T A + \beta C$ 1297
15.3.1 Axiom unit tests 1297
15.3.2 Axiom help page 1297
15.3.3 fortran code 1300
15.3.4 lisp code 1304
15.4 dsyrk - symmetric rank k $\alpha AA^T + \beta C$ or $\alpha A^T A + \beta C$ 1311
15.4.1 Axiom unit tests 1311
15.4.2 Axiom help page 1311
15.4.3 fortran code 1313
15.4.4 lisp code 1317
15.5 dtrmm - $\alpha op(A)B$ or $\alpha Bop(A)$, $op(A) = A$ or $op(X) = A^T$ 1323
15.5.1 Axiom unit tests 1323
15.5.2 Axiom help page 1323

15.5.3 fortran code . . . 1326
15.5.4 lisp code . . . 1330
15.6 dtrsm - $op(A)X = \alpha B$ or $Xop(A) = \alpha B$, $op(A) = A$ or $op(A) = A^T$ . . . 1340
15.6.1 Axiom unit tests . . . 1340
15.6.2 Axiom help page . . . 1340
15.6.3 fortran code . . . 1343
15.6.4 lisp code . . . 1348

16 BLAS Level 3 Complex Matrix-Matrix Operations 1359
16.1 cgemm - $\alpha op(A)op(B) + \beta C$, $op(X) = X$ or $op(X) = X^T$ or $op(X) = X^H$ . . . 1359
16.1.1 Axiom unit tests . . . 1359
16.1.2 Axiom help page . . . 1359
16.1.3 fortran code . . . 1362
16.1.4 lisp code . . . 1367
16.2 chemm - hermitian $\alpha AB + \beta C$ or $\alpha BA + \beta C$ . . . 1377
16.2.1 Axiom unit tests . . . 1377
16.2.2 Axiom help page . . . 1377
16.2.3 fortran code . . . 1380
16.2.4 lisp code . . . 1383
16.3 cher2k - hermitian rank 2 $\alpha AB^H + conjg(\alpha)BA^H + \beta C$ or $\alpha A^H B + conjg(\alpha)B^H A + \beta C$ . . . 1389
16.3.1 Axiom unit tests . . . 1389
16.3.2 Axiom help page . . . 1390
16.3.3 fortran code . . . 1392
16.3.4 lisp code . . . 1397
16.4 cherk - hermitian rank k $\alpha AA^H + \beta C$ or $\alpha A^H A + \beta C$ . . . 1407
16.4.1 Axiom unit tests . . . 1407
16.4.2 Axiom help page . . . 1407
16.4.3 fortran code . . . 1409
16.4.4 lisp code . . . 1414
16.5 csymm - symmetric $\alpha AB + \beta C$ or $\alpha BA + \beta C$ . . . 1423
16.5.1 Axiom unit tests . . . 1423
16.5.2 Axiom help page . . . 1423
16.5.3 fortran code . . . 1426
16.5.4 lisp code . . . 1429
16.6 csyr2k - symmetric rank 2k $\alpha AB^T + \alpha BA^T + \beta C$ or $\alpha A^T B + \alpha B^T A + \beta C$ . . . 1435
16.6.1 Axiom unit tests . . . 1435
16.6.2 Axiom help page . . . 1436
16.6.3 fortran code . . . 1438
16.6.4 lisp code . . . 1442
16.7 csyrk - symmetric $\alpha AA^T + \beta C$ or $\alpha A^T A + \beta C$ . . . 1449
16.7.1 Axiom unit tests . . . 1449
16.7.2 Axiom help page . . . 1449
16.7.3 fortran code . . . 1451
16.7.4 lisp code . . . 1455
16.8 ctrmm - $\alpha op(A)B$ or $\alpha Bop(A)$, $op(A) = A$ or $op(A) = A^T$ or $op(A) = A^H$ . . . 1461

16.8.1 Axiom unit tests 1461
16.8.2 Axiom help page 1461
16.8.3 fortran code 1464
16.8.4 lisp code 1469
16.9 ctrsm - triangular $op(A)X = \alpha B$ or $Xop(A) = \alpha B$, $op(A) = A$ or $op(A) = A^T$ or $op(A) = A^H$ 1480
16.9.1 Axiom unit tests 1480
16.9.2 Axiom help page 1481
16.9.3 fortran code 1483
16.9.4 lisp code 1489

17 BLAS Level 3 Complex16 Matrix-Matrix Operations 1503
17.1 zgemm - $\alpha op(A)op(B) + \beta C$, $op(X) = X$ or $op(X) = X^T$ or $op(X) = X^H$ . . 1503
17.1.1 Axiom unit tests 1503
17.1.2 Axiom help page 1503
17.1.3 fortran code 1506
17.1.4 lisp code 1512
17.2 zhemm - hermitian $\alpha AB + \beta C$ or $\alpha BA + \beta C$ 1521
17.2.1 Axiom unit tests 1521
17.2.2 Axiom help page 1522
17.2.3 fortran code 1524
17.2.4 lisp code 1528
17.3 zher2k - hermitian rank 2k $\alpha AB^H + conjg(\alpha)BA^H + \beta C$ or $\alpha A^H B + conjg(\alpha)B^H A + \beta C$ 1535
17.3.1 Axiom unit tests 1535
17.3.2 Axiom help page 1535
17.3.3 fortran code 1538
17.3.4 lisp code 1543
17.4 zherk - hermitian rank k $\alpha AA^H + \beta C$ or $\alpha A^H A + \beta C$ 1554
17.4.1 Axiom unit tests 1554
17.4.2 Axiom help page 1554
17.4.3 fortran code 1556
17.4.4 lisp code 1561
17.5 zsymm - symmetric $\alpha AB + \beta C$ or $\alpha BA + \beta C$ 1571
17.5.1 Axiom unit tests 1571
17.5.2 Axiom help page 1571
17.5.3 fortran code 1574
17.5.4 lisp code 1577
17.6 zsyr2k - symmetric rank 2k $\alpha AB^T + \alpha BA^T + \beta C$ or $\alpha A^T B + \alpha B^T A + \beta C$. 1584
17.6.1 Axiom unit tests 1584
17.6.2 Axiom help page 1584
17.6.3 fortran code 1587
17.6.4 lisp code 1591
17.7 zsyrk - symmetric rank k $\alpha AA^T + \beta C$ or $\alpha A^T A + \beta C$ 1598
17.7.1 Axiom unit tests 1598
17.7.2 Axiom help page 1598

17.7.3 fortran code . . . 1600
17.7.4 lisp code . . . 1604
17.8 ztrmm - triangular $\alpha op(A)B$ or $\alpha Bop(A)$, $op(A) = A$ or $op(A) = A^T$ or $op(A) = A^H$ . . . 1610
17.8.1 Axiom unit tests . . . 1610
17.8.2 Axiom help page . . . 1610
17.8.3 fortran code . . . 1613
17.8.4 lisp code . . . 1618
17.9 ztrsm - triangular $op(A)X = \alpha B$ $Xop(A) = \alpha B$, $op(A) = A$ or $op(A) = A^T$ or $op(A) = A^H$ . . . 1629
17.9.1 Axiom unit tests . . . 1629
17.9.2 Axiom help page . . . 1629
17.9.3 fortran code . . . 1632
17.9.4 lisp code . . . 1638

18 LAPACK Concepts 1651
18.1 Tridiagonal matrices [**?**] . . . 1651
18.2 Condition Number [**?**] . . . 1651
18.3 Euclidean Norm [**?**] . . . 1652

19 LAPACK Overview 1653
19.1 General Matrix . . . 1655
19.2 General Band Matrix . . . 1655
19.3 General Tridiagonal Matrix . . . 1655
19.4 Symmetric/Hermitian Positive Definite . . . 1656
19.5 Symmetric/Hermitian Positive Definite (packed storage) . . . 1656
19.6 Symmetric/Hermitian Positive Definite Band . . . 1656
19.7 Symmetric/Hermitian Positive Definite Tridiagonal . . . 1656
19.8 Symmetric/Hermitian Indefinite Matrix . . . 1657
19.9 Complex Symmetric Matrix . . . 1657
19.10Symmetric/Hermitian Indefinite Matrix (packed storage) . . . 1657
19.11Complex Symmetric (packed storage) Matrix . . . 1657
19.12Triangular Matrix . . . 1658
19.13Triangular Matrix (packed storage) . . . 1658
19.14Triangular Band Matrix . . . 1658

20 LAPACK - General Matrices, Linear Solve, Double 1659
20.1 dgels . . . 1659
20.1.1 Axiom unit tests . . . 1659
20.1.2 Axiom help page . . . 1659
20.1.3 fortran code . . . 1662
20.1.4 lisp code . . . 1668
20.2 dgelsd . . . 1678
20.2.1 Axiom unit tests . . . 1678
20.2.2 Axiom help page . . . 1678
20.2.3 fortran code . . . 1681

20.2.4 lisp code . . . 1689
20.3 dgelss . . . 1710
20.3.1 Axiom unit tests . . . 1710
20.3.2 Axiom help page . . . 1711
20.3.3 fortran code . . . 1713
20.3.4 lisp code . . . 1724
20.4 dgelsx - DEPRECATED. Use dgelsy . . . 1749
20.5 dgelsy . . . 1749
20.5.1 Axiom unit tests . . . 1749
20.5.2 Axiom help page . . . 1749
20.5.3 fortran code . . . 1752
20.5.4 lisp code . . . 1757
20.6 dgesv . . . 1767
20.6.1 Axiom unit tests . . . 1767
20.6.2 Axiom help page . . . 1768
20.6.3 fortran code . . . 1769
20.6.4 lisp code . . . 1770
20.7 dgesvx . . . 1771
20.7.1 Axiom unit tests . . . 1771
20.7.2 Axiom help page . . . 1771
20.7.3 fortran code . . . 1776
20.7.4 lisp code . . . 1781
20.8 dgesvxx . . . 1790
20.8.1 Axiom unit tests . . . 1790
20.8.2 Axiom help page . . . 1790
20.8.3 fortran code . . . 1798
20.8.4 lisp code . . . 1803
20.9 dsgesv . . . 1810
20.9.1 Axiom unit tests . . . 1810
20.9.2 Axiom help page . . . 1811
20.9.3 fortran code . . . 1813
20.9.4 lisp code . . . 1818

21 LAPACK - General Matrices, Linear Solve, Real 1825
21.1 sgels . . . 1825
21.1.1 Axiom unit tests . . . 1825
21.1.2 Axiom help page . . . 1825
21.1.3 fortran code . . . 1828
21.1.4 lisp code . . . 1834
21.2 sgelsd . . . 1844
21.2.1 Axiom unit tests . . . 1844
21.2.2 Axiom help page . . . 1844
21.2.3 fortran code . . . 1847
21.2.4 lisp code . . . 1855
21.3 sgelss . . . 1876
21.3.1 Axiom unit tests . . . 1876

21.3.2 Axiom help page . . . 1876
21.3.3 fortran code . . . 1879
21.3.4 lisp code . . . 1889
21.4 sgelsx - DEPRECATED use sgelsy . . . 1915
21.5 sgelsy . . . 1915
21.5.1 Axiom unit tests . . . 1915
21.5.2 Axiom help page . . . 1915
21.5.3 fortran code . . . 1918
21.5.4 lisp code . . . 1923
21.6 sgesv . . . 1933
21.6.1 Axiom unit tests . . . 1933
21.6.2 Axiom help page . . . 1933
21.6.3 fortran code . . . 1935
21.6.4 lisp code . . . 1936
21.7 sgesvx . . . 1937
21.7.1 Axiom unit tests . . . 1937
21.7.2 Axiom help page . . . 1938
21.7.3 fortran code . . . 1943
21.7.4 lisp code . . . 1948
21.8 sgesvxx . . . 1957
21.8.1 Axiom unit tests . . . 1957
21.8.2 Axiom help page . . . 1957
21.8.3 fortran code . . . 1965
21.8.4 lisp code . . . 1970

22 LAPACK - General Matrices, Linear Solve, Complex 1979
22.1 cgels . . . 1979
22.1.1 Axiom unit tests . . . 1979
22.1.2 Axiom help page . . . 1979
22.1.3 fortran code . . . 1982
22.1.4 lisp code . . . 1988
22.2 cgelsd . . . 1998
22.2.1 Axiom unit tests . . . 1998
22.2.2 Axiom help page . . . 1998
22.2.3 fortran code . . . 2001
22.2.4 lisp code . . . 2009
22.3 cgelss . . . 2031
22.3.1 Axiom unit tests . . . 2031
22.3.2 Axiom help page . . . 2031
22.3.3 fortran code . . . 2033
22.3.4 lisp code . . . 2045
22.4 cgelsx - DEPRECATED use cgelsy . . . 2071
22.5 cgelsy . . . 2071
22.5.1 Axiom unit tests . . . 2071
22.5.2 Axiom help page . . . 2071
22.5.3 fortran code . . . 2074

22.5.4 lisp code . . . 2079
22.6 cgesv . . . 2089
22.6.1 Axiom unit tests . . . 2089
22.6.2 Axiom help page . . . 2089
22.6.3 fortran code . . . 2091
22.6.4 lisp code . . . 2092
22.7 cgesvx . . . 2094
22.7.1 Axiom unit tests . . . 2094
22.7.2 Axiom help page . . . 2094
22.7.3 fortran code . . . 2099
22.7.4 lisp code . . . 2104
22.8 cgesvxx . . . 2113
22.8.1 Axiom unit tests . . . 2113
22.8.2 Axiom help page [**?**] . . . 2113
22.8.3 fortran code . . . 2121
22.8.4 lisp code . . . 2126

23 LAPACK - General Matrices, Linear Solve, Complex16 2135
23.1 zcgesv . . . 2135
23.1.1 Axiom unit tests . . . 2135
23.1.2 Axiom help page . . . 2135
23.1.3 fortran code . . . 2138
23.1.4 lisp code . . . 2143
23.2 zgels . . . 2150
23.2.1 Axiom unit tests . . . 2150
23.2.2 Axiom help page . . . 2150
23.2.3 fortran code . . . 2153
23.2.4 lisp code . . . 2159
23.3 zgelsd . . . 2169
23.3.1 Axiom unit tests . . . 2169
23.3.2 Axiom help page . . . 2169
23.3.3 fortran code . . . 2172
23.3.4 lisp code . . . 2180
23.4 zgelss . . . 2201
23.4.1 Axiom unit tests . . . 2201
23.4.2 Axiom help page . . . 2201
23.4.3 fortran code . . . 2204
23.4.4 lisp code . . . 2215
23.5 zgelsx - DEPRECATED use zgelsy . . . 2241
23.6 zgelsy . . . 2241
23.6.1 Axiom unit tests . . . 2241
23.6.2 Axiom help page . . . 2241
23.6.3 fortran code . . . 2244
23.6.4 lisp code . . . 2249
23.7 zgesv . . . 2259
23.7.1 Axiom unit tests . . . 2259

23.7.2 Axiom help page . . . 2259
23.7.3 fortran code . . . 2261
23.7.4 lisp code . . . 2262
23.8 zgesvx . . . 2264
23.8.1 Axiom unit tests . . . 2264
23.8.2 Axiom help page . . . 2264
23.8.3 fortran code . . . 2269
23.8.4 lisp code . . . 2274
23.9 zgesvxx . . . 2283
23.9.1 Axiom unit tests . . . 2283
23.9.2 Axiom help page [**?**] . . . 2283
23.9.3 fortran code . . . 2291
23.9.4 lisp code . . . 2296

24 LAPACK - General Matrices, Eigenvalue , Double 2305
24.1 dgees . . . 2305
24.1.1 Axiom unit tests . . . 2305
24.1.2 Axiom help page . . . 2305
24.1.3 fortran code . . . 2308
24.1.4 lisp code . . . 2314
24.2 dgeesx . . . 2315
24.2.1 Axiom unit tests . . . 2315
24.2.2 Axiom help page . . . 2315
24.2.3 fortran code . . . 2319
24.2.4 lisp code . . . 2326
24.3 dgeev . . . 2326
24.3.1 Axiom unit tests . . . 2326
24.3.2 Axiom help page . . . 2326
24.3.3 fortran code . . . 2329
24.3.4 lisp code . . . 2335
24.4 dgeevx . . . 2335
24.4.1 Axiom unit tests . . . 2335
24.4.2 Axiom help page . . . 2336
24.4.3 fortran code . . . 2340
24.4.4 lisp code . . . 2347
24.5 dgegs - DEPRECATED use dgges . . . 2348
24.6 dgegv - DEPRECATED use dggev . . . 2348
24.7 dgges . . . 2348
24.7.1 Axiom unit tests . . . 2348
24.7.2 Axiom help page . . . 2348
24.7.3 fortran code . . . 2352
24.7.4 lisp code . . . 2360
24.8 dgges3 . . . 2360
24.8.1 Axiom unit tests . . . 2360
24.8.2 Axiom help page . . . 2360
24.8.3 fortran code . . . 2364

24.8.4 lisp code . . . 2371
24.9 dggesx . . . 2372
24.9.1 Axiom unit tests . . . 2372
24.9.2 Axiom help page . . . 2372
24.9.3 fortran code . . . 2377
24.9.4 lisp code . . . 2386
24.10dggev . . . 2386
24.10.1 Axiom unit tests . . . 2386
24.10.2 Axiom help page . . . 2386
24.10.3 fortran code . . . 2389
24.10.4 lisp code . . . 2396
24.11dggev3 . . . 2410
24.11.1 Axiom unit tests . . . 2410
24.11.2 Axiom help page . . . 2410
24.11.3 fortran code . . . 2413
24.11.4 lisp code . . . 2420
24.12dggevx . . . 2435
24.12.1 Axiom unit tests . . . 2435
24.12.2 Axiom help page . . . 2435
24.12.3 fortran code . . . 2441
24.12.4 lisp code . . . 2450

25 LAPACK - General Matrices, Eigenvalue , Real 2469
25.1 sgees . . . 2469
25.1.1 Axiom unit tests . . . 2469
25.1.2 Axiom help page . . . 2469
25.1.3 fortran code . . . 2472
25.1.4 lisp code . . . 2478
25.2 sgeesx . . . 2479
25.2.1 Axiom unit tests . . . 2479
25.2.2 Axiom help page . . . 2479
25.2.3 fortran code . . . 2483
25.2.4 lisp code . . . 2490
25.3 sgeev . . . 2490
25.3.1 Axiom unit tests . . . 2490
25.3.2 Axiom help page . . . 2490
25.3.3 fortran code . . . 2493
25.3.4 lisp code . . . 2499
25.4 sgeevx . . . 2513
25.4.1 Axiom unit tests . . . 2513
25.4.2 Axiom help page . . . 2514
25.4.3 fortran code . . . 2518
25.4.4 lisp code . . . 2525
25.5 sgegs - DEPRECATED use sgges . . . 2542
25.6 sgegv - DEPRECATED use sggev . . . 2542
25.7 sgges . . . 2542

25.7.1 Axiom unit tests . . . 2542
25.7.2 Axiom help page . . . 2542
25.7.3 fortran code . . . 2546
25.7.4 lisp code . . . 2554
25.8 sgges3 . . . 2554
25.8.1 Axiom unit tests . . . 2554
25.8.2 Axiom help page . . . 2554
25.8.3 fortran code . . . 2558
25.8.4 lisp code . . . 2565
25.9 sggesx . . . 2566
25.9.1 Axiom unit tests . . . 2566
25.9.2 Axiom help page . . . 2566
25.9.3 fortran code . . . 2571
25.9.4 lisp code . . . 2580
25.10 sggev . . . 2580
25.10.1 Axiom unit tests . . . 2580
25.10.2 Axiom help page . . . 2580
25.10.3 fortran code . . . 2583
25.10.4 lisp code . . . 2590
25.11 sggev3 . . . 2603
25.11.1 Axiom unit tests . . . 2603
25.11.2 Axiom help page . . . 2604
25.11.3 fortran code . . . 2607
25.11.4 lisp code . . . 2614
25.12 sggevx . . . 2628
25.12.1 Axiom unit tests . . . 2628
25.12.2 Axiom help page . . . 2628
25.12.3 fortran code . . . 2634
25.12.4 lisp code . . . 2643

26 LAPACK - General Matrices, Eigenvalue , Complex 2661
26.1 cgees . . . 2661
26.1.1 Axiom unit tests . . . 2661
26.1.2 Axiom help page . . . 2661
26.1.3 fortran code . . . 2664
26.1.4 lisp code . . . 2668
26.2 cgeesx . . . 2668
26.2.1 Axiom unit tests . . . 2668
26.2.2 Axiom help page . . . 2669
26.2.3 fortran code . . . 2672
26.2.4 lisp code . . . 2677
26.3 cgeev . . . 2677
26.3.1 Axiom unit tests . . . 2677
26.3.2 Axiom help page . . . 2678
26.3.3 fortran code . . . 2680
26.3.4 lisp code . . . 2686

26.4 cgeevx . . . 2698
26.4.1 Axiom unit tests . . . 2698
26.4.2 Axiom help page . . . 2698
26.4.3 fortran code . . . 2702
26.4.4 lisp code . . . 2709
26.5 cgegs - DEPRECATED use cgges . . . 2723
26.6 cgegv - DEPRECATED use cggev . . . 2723
26.7 cgges . . . 2723
26.7.1 Axiom unit tests . . . 2723
26.7.2 Axiom help page . . . 2724
26.7.3 fortran code . . . 2727
26.7.4 lisp code . . . 2734
26.8 cgges3 . . . 2734
26.8.1 Axiom unit tests . . . 2734
26.8.2 Axiom help page . . . 2734
26.8.3 fortran code . . . 2738
26.8.4 lisp code . . . 2744
26.9 cggesx . . . 2744
26.9.1 Axiom unit tests . . . 2744
26.9.2 Axiom help page . . . 2745
26.9.3 fortran code . . . 2749
26.9.4 lisp code . . . 2757
26.10 cggev . . . 2757
26.10.1 Axiom unit tests . . . 2757
26.10.2 Axiom help page . . . 2757
26.10.3 fortran code . . . 2760
26.10.4 lisp code . . . 2767
26.11 cggev3 . . . 2779
26.11.1 Axiom unit tests . . . 2779
26.11.2 Axiom help page . . . 2779
26.11.3 fortran code . . . 2782
26.11.4 lisp code . . . 2789
26.12 cggevx . . . 2802
26.12.1 Axiom unit tests . . . 2802
26.12.2 Axiom help page . . . 2802
26.12.3 fortran code . . . 2808
26.12.4 lisp code . . . 2816

27 LAPACK - General Matrices, Eigenvalue , Complex16 2833
27.1 zgees . . . 2833
27.1.1 Axiom unit tests . . . 2833
27.1.2 Axiom help page . . . 2833
27.1.3 fortran code . . . 2836
27.1.4 lisp code . . . 2840
27.2 zgeesx . . . 2840
27.2.1 Axiom unit tests . . . 2840

27.2.2 Axiom help page . . . 2841
27.2.3 fortran code . . . 2844
27.2.4 lisp code . . . 2849
27.3 zgeev . . . 2849
27.3.1 Axiom unit tests . . . 2849
27.3.2 Axiom help page . . . 2850
27.3.3 fortran code . . . 2852
27.3.4 lisp code . . . 2858
27.4 zgeevx . . . 2872
27.4.1 Axiom unit tests . . . 2872
27.4.2 Axiom help page . . . 2873
27.4.3 fortran code . . . 2877
27.4.4 lisp code . . . 2884
27.5 zgegs - DEPRECATED use zgges . . . 2898
27.6 zgegv - DEPRECATED use zggev . . . 2898
27.7 zgges . . . 2898
27.7.1 Axiom unit tests . . . 2898
27.7.2 Axiom help page . . . 2898
27.7.3 fortran code . . . 2902
27.7.4 lisp code . . . 2908
27.8 zgges3 . . . 2909
27.8.1 Axiom unit tests . . . 2909
27.8.2 Axiom help page . . . 2909
27.8.3 fortran code . . . 2913
27.8.4 lisp code . . . 2919
27.9 zggesx . . . 2919
27.9.1 Axiom unit tests . . . 2919
27.9.2 Axiom help page . . . 2919
27.9.3 fortran code . . . 2924
27.9.4 lisp code . . . 2931
27.10 zggev . . . 2932
27.10.1 Axiom unit tests . . . 2932
27.10.2 Axiom help page . . . 2932
27.10.3 fortran code . . . 2935
27.10.4 lisp code . . . 2941
27.11 zggev3 . . . 2954
27.11.1 Axiom unit tests . . . 2954
27.11.2 Axiom help page . . . 2954
27.11.3 fortran code . . . 2957
27.11.4 lisp code . . . 2963
27.12 zggevx . . . 2977
27.12.1 Axiom unit tests . . . 2977
27.12.2 Axiom help page . . . 2977
27.12.3 fortran code . . . 2982
27.12.4 lisp code . . . 2991

28 LAPACK - General Matrices, Singular Value, Double 3007
28.1 dgejsv . . . 3007
28.1.1 Axiom unit tests . . . 3007
28.1.2 Axiom help page . . . 3007
28.1.3 fortran code . . . 3014
28.1.4 lisp code . . . 3039
28.2 dgesdd . . . 3100
28.2.1 Axiom unit tests . . . 3100
28.2.2 Axiom help page . . . 3101
28.2.3 fortran code . . . 3104
28.2.4 lisp code . . . 3126
28.3 dgesvd . . . 3126
28.3.1 Axiom unit tests . . . 3126
28.3.2 Axiom help page . . . 3127
28.3.3 fortran code . . . 3130
28.3.4 lisp code . . . 3191
28.4 dgesvdx . . . 3211
28.4.1 Axiom unit tests . . . 3211
28.4.2 Axiom help page . . . 3211
28.4.3 fortran code . . . 3215
28.4.4 lisp code . . . 3225

29 LAPACK - General Matrices, Singular Value, Real 3247
29.1 sgejsv . . . 3247
29.1.1 Axiom unit tests . . . 3247
29.1.2 Axiom help page . . . 3247
29.1.3 fortran code . . . 3254
29.1.4 lisp code . . . 3279
29.2 sgesdd . . . 3340
29.2.1 Axiom unit tests . . . 3340
29.2.2 Axiom help page . . . 3340
29.2.3 fortran code . . . 3343
29.2.4 lisp code . . . 3366
29.3 sgesvd . . . 3433
29.3.1 Axiom unit tests . . . 3433
29.3.2 Axiom help page . . . 3434
29.3.3 fortran code . . . 3436
29.3.4 lisp code . . . 3497
29.4 sgesvdx . . . 3619
29.4.1 Axiom unit tests . . . 3619
29.4.2 Axiom help page . . . 3620
29.4.3 fortran code . . . 3623
29.4.4 lisp code . . . 3633

30 LAPACK - General Matrices, Singular Value, Complex 3655
30.1 cgejsv . . . 3655
30.1.1 Axiom unit tests . . . 3655
30.1.2 Axiom help page . . . 3655
30.1.3 fortran code . . . 3663
30.1.4 lisp code . . . 3688
30.2 cgesdd . . . 3750
30.2.1 Axiom unit tests . . . 3750
30.2.2 Axiom help page . . . 3750
30.2.3 fortran code . . . 3753
30.2.4 lisp code . . . 3787
30.3 cgesvd . . . 3888
30.3.1 Axiom unit tests . . . 3888
30.3.2 Axiom help page . . . 3888
30.3.3 fortran code . . . 3891
30.3.4 lisp code . . . 3956
30.4 cgesvdx . . . 4075
30.4.1 Axiom unit tests . . . 4075
30.4.2 Axiom help page . . . 4075
30.4.3 fortran code . . . 4078
30.4.4 lisp code . . . 4089

31 LAPACK - General Matrices, Singular Value, Complex16 4111
31.1 zgejsv . . . 4111
31.1.1 Axiom unit tests . . . 4111
31.1.2 Axiom help page . . . 4111
31.1.3 fortran code . . . 4119
31.1.4 lisp code . . . 4144
31.2 zgesdd . . . 4206
31.2.1 Axiom unit tests . . . 4206
31.2.2 Axiom help page . . . 4206
31.2.3 fortran code . . . 4209
31.2.4 lisp code . . . 4243
31.3 zgesvd . . . 4339
31.3.1 Axiom unit tests . . . 4339
31.3.2 Axiom help page . . . 4339
31.3.3 fortran code . . . 4342
31.3.4 lisp code . . . 4406
31.4 zgesvdx . . . 4525
31.4.1 Axiom unit tests . . . 4525
31.4.2 Axiom help page . . . 4525
31.4.3 fortran code . . . 4528
31.4.4 lisp code . . . 4539

32 LAPACK - General Matrices, Comp. Routines, Double 4561
32.1 dgebak . . . 4561
32.1.1 Axiom unit tests . . . 4561
32.1.2 Axiom help page . . . 4561
32.1.3 fortran code . . . 4563
32.1.4 lisp code . . . 4566
32.2 dgebal . . . 4566
32.2.1 Axiom unit tests . . . 4566
32.2.2 Axiom help page . . . 4566
32.2.3 fortran code . . . 4568
32.2.4 lisp code . . . 4573
32.3 dgebd2 . . . 4573
32.3.1 Axiom unit tests . . . 4573
32.3.2 Axiom help page . . . 4573
32.3.3 fortran code . . . 4576
32.3.4 lisp code . . . 4578
32.4 dgebrd . . . 4579
32.4.1 Axiom unit tests . . . 4579
32.4.2 Axiom help page . . . 4579
32.4.3 fortran code . . . 4582
32.4.4 lisp code . . . 4585
32.5 dgecon . . . 4585
32.5.1 Axiom unit tests . . . 4585
32.5.2 Axiom help page . . . 4585
32.5.3 fortran code . . . 4587
32.5.4 lisp code . . . 4590
32.6 dgeequ . . . 4593
32.6.1 Axiom unit tests . . . 4593
32.6.2 Axiom help page . . . 4593
32.6.3 fortran code . . . 4595
32.6.4 lisp code . . . 4598
32.7 dgeequb . . . 4602
32.7.1 Axiom unit tests . . . 4602
32.7.2 Axiom help page . . . 4602
32.7.3 fortran code . . . 4604
32.7.4 lisp code . . . 4607
32.8 dgehd2 . . . 4611
32.8.1 Axiom unit tests . . . 4611
32.8.2 Axiom help page . . . 4611
32.8.3 fortran code . . . 4613
32.8.4 lisp code . . . 4615
32.9 dgehrd . . . 4615
32.9.1 Axiom unit tests . . . 4615
32.9.2 Axiom help page . . . 4615
32.9.3 fortran code . . . 4617
32.9.4 lisp code . . . 4621

32.10dgelq2 4621
32.10.1 Axiom unit tests 4621
32.10.2 Axiom help page 4622
32.10.3 fortran code 4623
32.10.4 lisp code 4625
32.11dgelqf 4625
32.11.1 Axiom unit tests 4625
32.11.2 Axiom help page 4625
32.11.3 fortran code 4627
32.11.4 lisp code 4629
32.12dgemqrt 4630
32.12.1 Axiom unit tests 4630
32.12.2 Axiom help page 4630
32.12.3 fortran code 4632
32.12.4 lisp code 4635
32.13dgeql2 4639
32.13.1 Axiom unit tests 4639
32.13.2 Axiom help page 4639
32.13.3 fortran code 4641
32.13.4 lisp code 4642
32.14dgeqlf 4644
32.14.1 Axiom unit tests 4644
32.14.2 Axiom help page 4645
32.14.3 fortran code 4646
32.14.4 lisp code 4649
32.15dgeqp3 4653
32.15.1 Axiom unit tests 4653
32.15.2 Axiom help page 4653
32.15.3 fortran code 4655
32.15.4 lisp code 4659
32.16dgeqpf - DEPRECATED use dgeqp3 4665
32.17dgeqr2 4665
32.17.1 Axiom unit tests 4665
32.17.2 Axiom help page 4665
32.17.3 fortran code 4667
32.17.4 lisp code 4669
32.18dgeqr2p 4670
32.18.1 Axiom unit tests 4670
32.18.2 Axiom help page [**?**] 4671
32.18.3 fortran code 4672
32.18.4 lisp code 4674
32.19dgeqrf 4675
32.19.1 Axiom unit tests 4675
32.19.2 Axiom help page 4676
32.19.3 fortran code 4677
32.19.4 lisp code 4680

32.20dgeqrfp 4684
32.20.1 Axiom unit tests 4684
32.20.2 Axiom help page [?] 4684
32.20.3 fortran code 4686
32.20.4 lisp code 4688
32.21dgeqrt 4692
32.21.1 Axiom unit tests 4692
32.21.2 Axiom help page 4692
32.21.3 fortran code 4694
32.21.4 lisp code 4696
32.22dgeqrt2 4698
32.22.1 Axiom unit tests 4698
32.22.2 Axiom help page 4698
32.22.3 fortran code 4700
32.22.4 lisp code 4702
32.23dgeqrt3 4705
32.23.1 Axiom unit tests 4705
32.23.2 Axiom help page [?] 4705
32.23.3 fortran code 4708
32.23.4 lisp code 4710
32.24dgerfs 4715
32.24.1 Axiom unit tests 4715
32.24.2 Axiom help page 4715
32.24.3 fortran code 4717
32.24.4 lisp code 4722
32.25dgerfsx 4730
32.25.1 Axiom unit tests 4730
32.25.2 Axiom help page [?] 4730
32.25.3 fortran code 4736
32.25.4 lisp code 4742
32.26dgerq2 4742
32.26.1 Axiom unit tests 4742
32.26.2 Axiom help page 4743
32.26.3 fortran code 4744
32.26.4 lisp code 4746
32.27dgerqf 4748
32.27.1 Axiom unit tests 4748
32.27.2 Axiom help page 4748
32.27.3 fortran code 4750
32.27.4 lisp code 4753
32.28dgesvj 4756
32.28.1 Axiom unit tests 4756
32.28.2 Axiom help page 4757
32.28.3 fortran code 4761
32.28.4 lisp code 4785
32.29dgetf2 4849

32.29.1 Axiom unit tests . . . 4849
32.29.2 Axiom help page . . . 4849
32.29.3 fortran code . . . 4851
32.29.4 lisp code . . . 4853
32.30 dgetrf . . . 4853
32.30.1 Axiom unit tests . . . 4853
32.30.2 Axiom help page . . . 4853
32.30.3 fortran code . . . 4855
32.30.4 lisp code . . . 4857
32.31 dgetrf2 . . . 4860
32.31.1 Axiom unit tests . . . 4860
32.31.2 Axiom help page . . . 4861
32.31.3 fortran code . . . 4862
32.31.4 lisp code . . . 4865
32.32 dgetri . . . 4869
32.32.1 Axiom unit tests . . . 4869
32.32.2 Axiom help page . . . 4869
32.32.3 fortran code . . . 4870
32.32.4 lisp code . . . 4873
32.33 dgetrs . . . 4878
32.33.1 Axiom unit tests . . . 4878
32.33.2 Axiom help page . . . 4878
32.33.3 fortran code . . . 4879
32.33.4 lisp code . . . 4881
32.34 dhgeqz . . . 4882
32.34.1 Axiom unit tests . . . 4882
32.34.2 Axiom help page [**?**] . . . 4882
32.34.3 fortran code . . . 4886
32.34.4 lisp code . . . 4906
32.35 dla_geamv . . . 4948
32.35.1 Axiom unit tests . . . 4948
32.35.2 Axiom help page . . . 4948
32.35.3 fortran code . . . 4950
32.35.4 lisp code . . . 4955
32.36 dla_gercond . . . 4960
32.36.1 Axiom unit tests . . . 4960
32.36.2 Axiom help page . . . 4960
32.36.3 fortran code . . . 4962
32.36.4 lisp code . . . 4966
32.37 dla_gerfsx_extended . . . 4972
32.37.1 Axiom unit tests . . . 4972
32.37.2 Axiom help page [**?**] . . . 4972
32.37.3 fortran code . . . 4978
32.37.4 lisp code . . . 4983
32.38 dla_gerpvgrw . . . 4991
32.38.1 Axiom unit tests . . . 4991

32.38.2 Axiom help page . . . 4991
32.38.3 fortran code . . . 4992
32.38.4 lisp code . . . 4993
32.39 dtgevc . . . 4994
32.39.1 Axiom unit tests . . . 4994
32.39.2 Axiom help page . . . 4995
32.39.3 fortran code . . . 4999
32.39.4 lisp code . . . 5016
32.40 dtgexc . . . 5051
32.40.1 Axiom unit tests . . . 5051
32.40.2 Axiom help page . . . 5051
32.40.3 fortran code . . . 5054
32.40.4 lisp code . . . 5060
32.41 zgesvj . . . 5068
32.41.1 Axiom unit tests . . . 5068
32.41.2 Axiom help page . . . 5068
32.41.3 fortran code . . . 5073
32.41.4 lisp code . . . 5093

33 LAPACK - General Matrices, Comp. Routines, Real 5141
33.1 sgebak . . . 5141
33.1.1 Axiom unit tests . . . 5141
33.1.2 Axiom help page . . . 5141
33.1.3 fortran code . . . 5143
33.1.4 lisp code . . . 5146
33.2 sgebal . . . 5150
33.2.1 Axiom unit tests . . . 5150
33.2.2 Axiom help page . . . 5150
33.2.3 fortran code . . . 5152
33.2.4 lisp code . . . 5157
33.3 sgebd2 . . . 5163
33.3.1 Axiom unit tests . . . 5163
33.3.2 Axiom help page . . . 5163
33.3.3 fortran code . . . 5166
33.3.4 lisp code . . . 5169
33.4 sgebrd . . . 5173
33.4.1 Axiom unit tests . . . 5173
33.4.2 Axiom help page . . . 5173
33.4.3 fortran code . . . 5176
33.4.4 lisp code . . . 5179
33.5 sgecon . . . 5184
33.5.1 Axiom unit tests . . . 5184
33.5.2 Axiom help page . . . 5184
33.5.3 fortran code . . . 5186
33.5.4 lisp code . . . 5188
33.6 sgeequ . . . 5192

33.6.1 Axiom unit tests . . . 5192
33.6.2 Axiom help page . . . 5192
33.6.3 fortran code . . . 5194
33.6.4 lisp code . . . 5197
33.7 sgeequb . . . 5200
33.7.1 Axiom unit tests . . . 5200
33.7.2 Axiom help page . . . 5201
33.7.3 fortran code . . . 5202
33.7.4 lisp code . . . 5206
33.8 sgehd2 . . . 5210
33.8.1 Axiom unit tests . . . 5210
33.8.2 Axiom help page . . . 5210
33.8.3 fortran code . . . 5212
33.8.4 lisp code . . . 5213
33.9 sgehrd . . . 5216
33.9.1 Axiom unit tests . . . 5216
33.9.2 Axiom help page . . . 5216
33.9.3 fortran code . . . 5218
33.9.4 lisp code . . . 5222
33.10 sgelq2 . . . 5228
33.10.1 Axiom unit tests . . . 5228
33.10.2 Axiom help page . . . 5228
33.10.3 fortran code . . . 5229
33.10.4 lisp code . . . 5231
33.11 sgelqf . . . 5233
33.11.1 Axiom unit tests . . . 5233
33.11.2 Axiom help page . . . 5233
33.11.3 fortran code . . . 5235
33.11.4 lisp code . . . 5237
33.12 sgemqrt . . . 5241
33.12.1 Axiom unit tests . . . 5241
33.12.2 Axiom help page . . . 5241
33.12.3 fortran code . . . 5243
33.12.4 lisp code . . . 5246
33.13 sgeql2 . . . 5250
33.13.1 Axiom unit tests . . . 5250
33.13.2 Axiom help page . . . 5251
33.13.3 fortran code . . . 5252
33.13.4 lisp code . . . 5254
33.14 sgeqlf . . . 5256
33.14.1 Axiom unit tests . . . 5256
33.14.2 Axiom help page . . . 5256
33.14.3 fortran code . . . 5258
33.14.4 lisp code . . . 5261
33.15 sgeqp3 . . . 5264
33.15.1 Axiom unit tests . . . 5264

33.15.2 Axiom help page . . . 5265
33.15.3 fortran code . . . 5267
33.15.4 lisp code . . . 5271
33.16 sgeqpf - DEPRECATED use sgeqp3 . . . 5276
33.17 sgeqr2 . . . 5276
33.17.1 Axiom unit tests . . . 5276
33.17.2 Axiom help page . . . 5277
33.17.3 fortran code . . . 5278
33.17.4 lisp code . . . 5280
33.18 sgeqr2p . . . 5281
33.18.1 Axiom unit tests . . . 5281
33.18.2 Axiom help page [**?**] . . . 5282
33.18.3 fortran code . . . 5283
33.18.4 lisp code . . . 5285
33.19 sgeqrf . . . 5286
33.19.1 Axiom unit tests . . . 5286
33.19.2 Axiom help page . . . 5287
33.19.3 fortran code . . . 5288
33.19.4 lisp code . . . 5291
33.20 sgeqrfp . . . 5295
33.20.1 Axiom unit tests . . . 5295
33.20.2 Axiom help page [**?**] . . . 5295
33.20.3 fortran code . . . 5297
33.20.4 lisp code . . . 5299
33.21 sgeqrt . . . 5303
33.21.1 Axiom unit tests . . . 5303
33.21.2 Axiom help page . . . 5303
33.21.3 fortran code . . . 5305
33.21.4 lisp code . . . 5307
33.22 sgeqrt2 . . . 5309
33.22.1 Axiom unit tests . . . 5309
33.22.2 Axiom help page . . . 5309
33.22.3 fortran code . . . 5311
33.22.4 lisp code . . . 5313
33.23 sgeqrt3 . . . 5316
33.23.1 Axiom unit tests . . . 5316
33.23.2 Axiom help page [**?**] . . . 5316
33.23.3 fortran code . . . 5318
33.23.4 lisp code . . . 5321
33.24 sgerfs . . . 5325
33.24.1 Axiom unit tests . . . 5325
33.24.2 Axiom help page . . . 5325
33.24.3 fortran code . . . 5328
33.24.4 lisp code . . . 5333
33.25 sgerfsx . . . 5340
33.25.1 Axiom unit tests . . . 5340

33.25.2 Axiom help page [?] . . . 5340
33.25.3 fortran code . . . 5346
33.25.4 lisp code . . . 5352
33.26 sgerq2 . . . 5352
33.26.1 Axiom unit tests . . . 5352
33.26.2 Axiom help page . . . 5353
33.26.3 fortran code . . . 5354
33.26.4 lisp code . . . 5356
33.27 sgerqf . . . 5358
33.27.1 Axiom unit tests . . . 5358
33.27.2 Axiom help page . . . 5358
33.27.3 fortran code . . . 5360
33.27.4 lisp code . . . 5363
33.28 sgesvj . . . 5367
33.28.1 Axiom unit tests . . . 5367
33.28.2 Axiom help page . . . 5367
33.28.3 fortran code . . . 5371
33.28.4 lisp code . . . 5395
33.29 sgetf2 . . . 5459
33.29.1 Axiom unit tests . . . 5459
33.29.2 Axiom help page . . . 5460
33.29.3 fortran code . . . 5461
33.29.4 lisp code . . . 5463
33.30 sgetrf . . . 5466
33.30.1 Axiom unit tests . . . 5466
33.30.2 Axiom help page . . . 5466
33.30.3 fortran code . . . 5467
33.30.4 lisp code . . . 5470
33.31 sgetrf2 . . . 5473
33.31.1 Axiom unit tests . . . 5473
33.31.2 Axiom help page . . . 5473
33.31.3 fortran code . . . 5475
33.31.4 lisp code . . . 5478
33.32 sgetri . . . 5481
33.32.1 Axiom unit tests . . . 5481
33.32.2 Axiom help page . . . 5481
33.32.3 fortran code . . . 5483
33.32.4 lisp code . . . 5486
33.33 sgetrs . . . 5490
33.33.1 Axiom unit tests . . . 5490
33.33.2 Axiom help page . . . 5490
33.33.3 fortran code . . . 5492
33.33.4 lisp code . . . 5494
33.34 shgeqz . . . 5497
33.34.1 Axiom unit tests . . . 5497
33.34.2 Axiom help page [?] . . . 5497

33.34.3 fortran code . . . 5501
33.34.4 lisp code . . . 5521
33.35 sla_geamv . . . 5562
33.35.1 Axiom unit tests . . . 5562
33.35.2 Axiom help page . . . 5563
33.35.3 fortran code . . . 5565
33.35.4 lisp code . . . 5569
33.36 sla_gercond . . . 5575
33.36.1 Axiom unit tests . . . 5575
33.36.2 Axiom help page . . . 5575
33.36.3 fortran code . . . 5577
33.36.4 lisp code . . . 5581
33.37 sla_gerfsx_extended . . . 5586
33.37.1 Axiom unit tests . . . 5586
33.37.2 Axiom help page [**?**] . . . 5587
33.37.3 fortran code . . . 5592
33.37.4 lisp code . . . 5598
33.38 sla_gerpvgrw . . . 5605
33.38.1 Axiom unit tests . . . 5605
33.38.2 Axiom help page . . . 5606
33.38.3 fortran code . . . 5607
33.38.4 lisp code . . . 5608
33.39 stgevc . . . 5609
33.39.1 Axiom unit tests . . . 5609
33.39.2 Axiom help page . . . 5609
33.39.3 fortran code . . . 5614
33.39.4 lisp code . . . 5631
33.40 stgexc . . . 5665
33.40.1 Axiom unit tests . . . 5665
33.40.2 Axiom help page . . . 5665
33.40.3 fortran code . . . 5668
33.40.4 lisp code . . . 5674

34 LAPACK - General Matrices, Comp. Routines, Complex 5683
34.1 cgebak . . . 5683
34.1.1 Axiom unit tests . . . 5683
34.1.2 Axiom help page . . . 5683
34.1.3 fortran code . . . 5685
34.1.4 lisp code . . . 5688
34.2 cgebal . . . 5692
34.2.1 Axiom unit tests . . . 5692
34.2.2 Axiom help page . . . 5692
34.2.3 fortran code . . . 5695
34.2.4 lisp code . . . 5699
34.3 cgebd2 . . . 5706
34.3.1 Axiom unit tests . . . 5706

34.3.2 Axiom help page . . . 5706
34.3.3 fortran code . . . 5709
34.3.4 lisp code . . . 5711
34.4 cgebrd . . . 5717
34.4.1 Axiom unit tests . . . 5717
34.4.2 Axiom help page . . . 5717
34.4.3 fortran code . . . 5720
34.4.4 lisp code . . . 5723
34.5 cgecon . . . 5728
34.5.1 Axiom unit tests . . . 5728
34.5.2 Axiom help page . . . 5728
34.5.3 fortran code . . . 5730
34.5.4 lisp code . . . 5732
34.6 cgeequ . . . 5736
34.6.1 Axiom unit tests . . . 5736
34.6.2 Axiom help page . . . 5736
34.6.3 fortran code . . . 5738
34.6.4 lisp code . . . 5741
34.7 cgeequb . . . 5745
34.7.1 Axiom unit tests . . . 5745
34.7.2 Axiom help page . . . 5745
34.7.3 fortran code . . . 5747
34.7.4 lisp code . . . 5751
34.8 cgehd2 . . . 5754
34.8.1 Axiom unit tests . . . 5754
34.8.2 Axiom help page . . . 5755
34.8.3 fortran code . . . 5757
34.8.4 lisp code . . . 5758
34.9 cgehrd . . . 5761
34.9.1 Axiom unit tests . . . 5761
34.9.2 Axiom help page . . . 5761
34.9.3 fortran code . . . 5763
34.9.4 lisp code . . . 5767
34.10 cgelq2 . . . 5773
34.10.1 Axiom unit tests . . . 5773
34.10.2 Axiom help page . . . 5773
34.10.3 fortran code . . . 5775
34.10.4 lisp code . . . 5776
34.11 cgelqf . . . 5778
34.11.1 Axiom unit tests . . . 5778
34.11.2 Axiom help page . . . 5779
34.11.3 fortran code . . . 5780
34.11.4 lisp code . . . 5783
34.12 cgemqrt . . . 5786
34.12.1 Axiom unit tests . . . 5786
34.12.2 Axiom help page . . . 5787

34.12.3 fortran code . . . 5789
34.12.4 lisp code . . . 5791
34.13 cgeql2 . . . 5796
34.13.1 Axiom unit tests . . . 5796
34.13.2 Axiom help page . . . 5796
34.13.3 fortran code . . . 5798
34.13.4 lisp code . . . 5799
34.14 cgeqlf . . . 5801
34.14.1 Axiom unit tests . . . 5801
34.14.2 Axiom help page . . . 5801
34.14.3 fortran code . . . 5803
34.14.4 lisp code . . . 5806
34.15 cgeqp3 . . . 5810
34.15.1 Axiom unit tests . . . 5810
34.15.2 Axiom help page . . . 5810
34.15.3 fortran code . . . 5812
34.15.4 lisp code . . . 5816
34.16 cgeqpf - DEPRECATED use cgeqp3 . . . 5822
34.17 cgeqr2 . . . 5822
34.17.1 Axiom unit tests . . . 5822
34.17.2 Axiom help page . . . 5822
34.17.3 fortran code . . . 5824
34.17.4 lisp code . . . 5825
34.18 cgeqr2p . . . 5827
34.18.1 Axiom unit tests . . . 5827
34.18.2 Axiom help page [**?**] . . . 5827
34.18.3 fortran code . . . 5829
34.18.4 lisp code . . . 5830
34.19 cgeqrf . . . 5832
34.19.1 Axiom unit tests . . . 5832
34.19.2 Axiom help page . . . 5832
34.19.3 fortran code . . . 5834
34.19.4 lisp code . . . 5837
34.20 cgeqrfp . . . 5840
34.20.1 Axiom unit tests . . . 5840
34.20.2 Axiom help page [**?**] . . . 5841
34.20.3 fortran code . . . 5842
34.20.4 lisp code . . . 5845
34.21 cgeqrt . . . 5849
34.21.1 Axiom unit tests . . . 5849
34.21.2 Axiom help page . . . 5849
34.21.3 fortran code . . . 5851
34.21.4 lisp code . . . 5852
34.22 cgeqrt2 . . . 5855
34.22.1 Axiom unit tests . . . 5855
34.22.2 Axiom help page . . . 5855

34.22.3 fortran code . . . 5857
34.22.4 lisp code . . . 5859
34.23 cgeqrt3 . . . 5862
34.23.1 Axiom unit tests . . . 5862
34.23.2 Axiom help page [**?**] . . . 5862
34.23.3 fortran code . . . 5864
34.23.4 lisp code . . . 5866
34.24 cgerfs . . . 5871
34.24.1 Axiom unit tests . . . 5871
34.24.2 Axiom help page . . . 5871
34.24.3 fortran code . . . 5874
34.24.4 lisp code . . . 5879
34.25 cgerfsx . . . 5886
34.25.1 Axiom unit tests . . . 5886
34.25.2 Axiom help page [**?**] . . . 5886
34.25.3 fortran code . . . 5892
34.25.4 lisp code . . . 5899
34.26 cgerq2 . . . 5899
34.26.1 Axiom unit tests . . . 5899
34.26.2 Axiom help page . . . 5899
34.26.3 fortran code . . . 5901
34.26.4 lisp code . . . 5902
34.27 cgerqf . . . 5904
34.27.1 Axiom unit tests . . . 5904
34.27.2 Axiom help page . . . 5905
34.27.3 fortran code . . . 5907
34.27.4 lisp code . . . 5909
34.28 cgesvj . . . 5913
34.28.1 Axiom unit tests . . . 5913
34.28.2 Axiom help page . . . 5914
34.28.3 fortran code . . . 5918
34.28.4 lisp code . . . 5938
34.29 cgetf2 . . . 5984
34.29.1 Axiom unit tests . . . 5984
34.29.2 Axiom help page . . . 5984
34.29.3 fortran code . . . 5985
34.29.4 lisp code . . . 5987
34.30 cgetrf . . . 5990
34.30.1 Axiom unit tests . . . 5990
34.30.2 Axiom help page . . . 5990
34.30.3 fortran code . . . 5992
34.30.4 lisp code . . . 5994
34.31 cgetrf2 . . . 5997
34.31.1 Axiom unit tests . . . 5997
34.31.2 Axiom help page . . . 5998
34.31.3 fortran code . . . 5999

34.31.4 lisp code . . . 6003
34.32 cgetri . . . 6006
34.32.1 Axiom unit tests . . . 6006
34.32.2 Axiom help page . . . 6006
34.32.3 fortran code . . . 6008
34.32.4 lisp code . . . 6010
34.33 cgetrs . . . 6015
34.33.1 Axiom unit tests . . . 6015
34.33.2 Axiom help page . . . 6015
34.33.3 fortran code . . . 6017
34.33.4 lisp code . . . 6019
34.34 chgeqz . . . 6022
34.34.1 Axiom unit tests . . . 6022
34.34.2 Axiom help page [?] . . . 6022
34.34.3 fortran code . . . 6026
34.34.4 lisp code . . . 6037
34.35 cla_geamv . . . 6061
34.35.1 Axiom unit tests . . . 6061
34.35.2 Axiom help page . . . 6061
34.35.3 fortran code . . . 6063
34.35.4 lisp code . . . 6068
34.36 cla_gercond_c . . . 6074
34.36.1 Axiom unit tests . . . 6074
34.36.2 Axiom help page . . . 6074
34.36.3 fortran code . . . 6076
34.36.4 lisp code . . . 6079
34.37 cla_gercond_x . . . 6084
34.37.1 Axiom unit tests . . . 6084
34.37.2 Axiom help page . . . 6085
34.37.3 fortran code . . . 6086
34.37.4 lisp code . . . 6090
34.38 cla_gerfsx_extended . . . 6094
34.38.1 Axiom unit tests . . . 6094
34.38.2 Axiom help page [?] . . . 6094
34.38.3 fortran code . . . 6100
34.38.4 lisp code . . . 6106
34.39 cla_gerpvgrw . . . 6113
34.39.1 Axiom unit tests . . . 6113
34.39.2 Axiom help page . . . 6114
34.39.3 fortran code . . . 6115
34.39.4 lisp code . . . 6116
34.40 ctgevc . . . 6118
34.40.1 Axiom unit tests . . . 6118
34.40.2 Axiom help page . . . 6118
34.40.3 fortran code . . . 6121
34.40.4 lisp code . . . 6131

34.41 ctgexc . . . 6145
34.41.1 Axiom unit tests . . . 6145
34.41.2 Axiom help page . . . 6146
34.41.3 fortran code . . . 6148
34.41.4 lisp code . . . 6150

35 LAPACK - General Matrices, Comp. Routines, Complex16 6153
35.1 zgebak . . . 6153
35.1.1 Axiom unit tests . . . 6153
35.1.2 Axiom help page . . . 6153
35.1.3 fortran code . . . 6155
35.1.4 lisp code . . . 6158
35.2 zgebal . . . 6158
35.2.1 Axiom unit tests . . . 6158
35.2.2 Axiom help page . . . 6158
35.2.3 fortran code . . . 6160
35.2.4 lisp code . . . 6165
35.3 zgebd2 . . . 6165
35.3.1 Axiom unit tests . . . 6165
35.3.2 Axiom help page . . . 6165
35.3.3 fortran code . . . 6168
35.3.4 lisp code . . . 6171
35.4 zgebrd . . . 6176
35.4.1 Axiom unit tests . . . 6176
35.4.2 Axiom help page . . . 6176
35.4.3 fortran code . . . 6179
35.4.4 lisp code . . . 6182
35.5 zgecon . . . 6187
35.5.1 Axiom unit tests . . . 6187
35.5.2 Axiom help page . . . 6188
35.5.3 fortran code . . . 6189
35.5.4 lisp code . . . 6192
35.6 zgeequ . . . 6196
35.6.1 Axiom unit tests . . . 6196
35.6.2 Axiom help page . . . 6196
35.6.3 fortran code . . . 6198
35.6.4 lisp code . . . 6201
35.7 zgeequb . . . 6204
35.7.1 Axiom unit tests . . . 6204
35.7.2 Axiom help page . . . 6205
35.7.3 fortran code . . . 6207
35.7.4 lisp code . . . 6210
35.8 zgehd2 . . . 6214
35.8.1 Axiom unit tests . . . 6214
35.8.2 Axiom help page . . . 6214
35.8.3 fortran code . . . 6216

35.8.4 lisp code . . . 6218
35.9 zgehrd . . . 6218
35.9.1 Axiom unit tests . . . 6218
35.9.2 Axiom help page . . . 6219
35.9.3 fortran code . . . 6221
35.9.4 lisp code . . . 6224
35.10zgelq2 . . . 6225
35.10.1 Axiom unit tests . . . 6225
35.10.2 Axiom help page . . . 6225
35.10.3 fortran code . . . 6226
35.10.4 lisp code . . . 6228
35.11zgelqf . . . 6230
35.11.1 Axiom unit tests . . . 6230
35.11.2 Axiom help page . . . 6230
35.11.3 fortran code . . . 6232
35.11.4 lisp code . . . 6235
35.12zgemqrt . . . 6238
35.12.1 Axiom unit tests . . . 6238
35.12.2 Axiom help page . . . 6239
35.12.3 fortran code . . . 6241
35.12.4 lisp code . . . 6243
35.13zgeql2 . . . 6248
35.13.1 Axiom unit tests . . . 6248
35.13.2 Axiom help page . . . 6248
35.13.3 fortran code . . . 6250
35.13.4 lisp code . . . 6251
35.14zgeqlf . . . 6253
35.14.1 Axiom unit tests . . . 6253
35.14.2 Axiom help page . . . 6253
35.14.3 fortran code . . . 6255
35.14.4 lisp code . . . 6258
35.15zgeqp3 . . . 6262
35.15.1 Axiom unit tests . . . 6262
35.15.2 Axiom help page . . . 6262
35.15.3 fortran code . . . 6264
35.15.4 lisp code . . . 6268
35.16zgeqpf - DEPRECATED use zgeqp3 . . . 6274
35.17zgeqr2 . . . 6274
35.17.1 Axiom unit tests . . . 6274
35.17.2 Axiom help page . . . 6274
35.17.3 fortran code . . . 6276
35.17.4 lisp code . . . 6277
35.18zgeqr2p . . . 6279
35.18.1 Axiom unit tests . . . 6279
35.18.2 Axiom help page [**?**] . . . 6280
35.18.3 fortran code . . . 6281

35.18.4 lisp code 6283
35.19 zgeqrf 6284
35.19.1 Axiom unit tests 6284
35.19.2 Axiom help page 6285
35.19.3 fortran code 6286
35.19.4 lisp code 6289
35.20 zgeqrfp 6293
35.20.1 Axiom unit tests 6293
35.20.2 Axiom help page [**?**] 6293
35.20.3 fortran code 6295
35.20.4 lisp code 6297
35.21 zgeqrt 6301
35.21.1 Axiom unit tests 6301
35.21.2 Axiom help page 6301
35.21.3 fortran code 6303
35.21.4 lisp code 6305
35.22 zgeqrt2 6307
35.22.1 Axiom unit tests 6307
35.22.2 Axiom help page 6308
35.22.3 fortran code 6309
35.22.4 lisp code 6311
35.23 zgeqrt3 6314
35.23.1 Axiom unit tests 6314
35.23.2 Axiom help page [**?**] 6315
35.23.3 fortran code 6316
35.23.4 lisp code 6319
35.24 zgerfs 6324
35.24.1 Axiom unit tests 6324
35.24.2 Axiom help page 6324
35.24.3 fortran code 6326
35.24.4 lisp code 6332
35.25 zgerfsx 6339
35.25.1 Axiom unit tests 6339
35.25.2 Axiom help page [**?**] 6339
35.25.3 fortran code 6345
35.25.4 lisp code 6351
35.26 zgerq2 6352
35.26.1 Axiom unit tests 6352
35.26.2 Axiom help page 6352
35.26.3 fortran code 6354
35.26.4 lisp code 6355
35.27 zgerqf 6357
35.27.1 Axiom unit tests 6357
35.27.2 Axiom help page 6358
35.27.3 fortran code 6359
35.27.4 lisp code 6362

35.28zgetf2 . . . 6366
35.28.1 Axiom unit tests . . . 6366
35.28.2 Axiom help page . . . 6366
35.28.3 fortran code . . . 6368
35.28.4 lisp code . . . 6370
35.29zgetrf . . . 6373
35.29.1 Axiom unit tests . . . 6373
35.29.2 Axiom help page . . . 6373
35.29.3 fortran code . . . 6374
35.29.4 lisp code . . . 6377
35.30zgetrf2 . . . 6380
35.30.1 Axiom unit tests . . . 6380
35.30.2 Axiom help page . . . 6380
35.30.3 fortran code . . . 6382
35.30.4 lisp code . . . 6385
35.31zgetri . . . 6388
35.31.1 Axiom unit tests . . . 6388
35.31.2 Axiom help page . . . 6389
35.31.3 fortran code . . . 6390
35.31.4 lisp code . . . 6393
35.32zgetrs . . . 6398
35.32.1 Axiom unit tests . . . 6398
35.32.2 Axiom help page . . . 6398
35.32.3 fortran code . . . 6399
35.32.4 lisp code . . . 6401
35.33zhgeqz . . . 6404
35.33.1 Axiom unit tests . . . 6404
35.33.2 Axiom help page [**?**] . . . 6405
35.33.3 fortran code . . . 6408
35.33.4 lisp code . . . 6420
35.34zla_geamv . . . 6444
35.34.1 Axiom unit tests . . . 6444
35.34.2 Axiom help page . . . 6444
35.34.3 fortran code . . . 6446
35.34.4 lisp code . . . 6451
35.35zla_gercond_c . . . 6457
35.35.1 Axiom unit tests . . . 6457
35.35.2 Axiom help page . . . 6457
35.35.3 fortran code . . . 6459
35.35.4 lisp code . . . 6462
35.36zla_gercond_x . . . 6467
35.36.1 Axiom unit tests . . . 6468
35.36.2 Axiom help page . . . 6468
35.36.3 fortran code . . . 6470
35.36.4 lisp code . . . 6473
35.37zla_gerfsx_extended . . . 6477

35.37.1 Axiom unit tests . . . 6477
35.37.2 Axiom help page [?] . . . 6478
35.37.3 fortran code . . . 6483
35.37.4 lisp code . . . 6489
35.38 zla_gerpvgrw . . . 6497
35.38.1 Axiom unit tests . . . 6497
35.38.2 Axiom help page . . . 6497
35.38.3 fortran code . . . 6498
35.38.4 lisp code . . . 6499
35.39 ztgevc . . . 6501
35.39.1 Axiom unit tests . . . 6501
35.39.2 Axiom help page . . . 6501
35.39.3 fortran code . . . 6504
35.39.4 lisp code . . . 6514
35.40 ztgexc . . . 6529
35.40.1 Axiom unit tests . . . 6529
35.40.2 Axiom help page . . . 6529
35.40.3 fortran code . . . 6531
35.40.4 lisp code . . . 6533

36 LAPACK - General Matrices, Auxilliary Routines, Double 6537
36.1 dgesc2 . . . 6537
36.1.1 Axiom unit tests . . . 6537
36.1.2 Axiom help page . . . 6537
36.1.3 fortran code . . . 6539
36.1.4 lisp code . . . 6540
36.2 dgetc2 . . . 6543
36.2.1 Axiom unit tests . . . 6543
36.2.2 Axiom help page . . . 6543
36.2.3 fortran code . . . 6545
36.2.4 lisp code . . . 6547
36.3 dlange . . . 6549
36.3.1 Axiom unit tests . . . 6549
36.3.2 Axiom help page . . . 6550
36.3.3 fortran code . . . 6551
36.3.4 lisp code . . . 6553
36.4 dlaqge . . . 6553
36.4.1 Axiom unit tests . . . 6553
36.4.2 Axiom help page . . . 6554
36.4.3 fortran code . . . 6555
36.4.4 lisp code . . . 6557
36.5 dtgex2 . . . 6559
36.5.1 Axiom unit tests . . . 6559
36.5.2 Axiom help page . . . 6560
36.5.3 fortran code . . . 6562
36.5.4 lisp code . . . 6571

37 LAPACK - General Matrices, Auxilliary Routines, Real 6599
37.1 sgesc2 . . . 6599
37.1.1 Axiom unit tests . . . 6599
37.1.2 Axiom help page . . . 6599
37.1.3 fortran code . . . 6601
37.1.4 lisp code . . . 6602
37.2 sgetc2 . . . 6605
37.2.1 Axiom unit tests . . . 6605
37.2.2 Axiom help page . . . 6605
37.2.3 fortran code . . . 6607
37.2.4 lisp code . . . 6609
37.3 slange . . . 6611
37.3.1 Axiom unit tests . . . 6611
37.3.2 Axiom help page . . . 6612
37.3.3 fortran code . . . 6613
37.3.4 lisp code . . . 6615
37.4 slaqge . . . 6618
37.4.1 Axiom unit tests . . . 6618
37.4.2 Axiom help page . . . 6618
37.4.3 fortran code . . . 6620
37.4.4 lisp code . . . 6622
37.5 stgex2 . . . 6624
37.5.1 Axiom unit tests . . . 6624
37.5.2 Axiom help page . . . 6624
37.5.3 fortran code . . . 6627
37.5.4 lisp code . . . 6636

38 LAPACK - General Matrices, Auxilliary Routines, Complex 6659
38.1 cgesc2 . . . 6659
38.1.1 Axiom unit tests . . . 6659
38.1.2 Axiom help page . . . 6659
38.1.3 fortran code . . . 6661
38.1.4 lisp code . . . 6662
38.2 cgetc2 . . . 6665
38.2.1 Axiom unit tests . . . 6665
38.2.2 Axiom help page . . . 6665
38.2.3 fortran code . . . 6667
38.2.4 lisp code . . . 6669
38.3 clange . . . 6671
38.3.1 Axiom unit tests . . . 6671
38.3.2 Axiom help page . . . 6672
38.3.3 fortran code . . . 6673
38.3.4 lisp code . . . 6675
38.4 claqge . . . 6678
38.4.1 Axiom unit tests . . . 6678
38.4.2 Axiom help page . . . 6679

38.4.3 fortran code . . . 6681
38.4.4 lisp code . . . 6683
38.5 ctgex2 . . . 6685
38.5.1 Axiom unit tests . . . 6685
38.5.2 Axiom help page . . . 6685
38.5.3 fortran code . . . 6687
38.5.4 lisp code . . . 6690

39 LAPACK - General Matrices, Auxilliary Routines, Complex16 6697
39.1 zgesc2 . . . 6697
39.1.1 Axiom unit tests . . . 6697
39.1.2 Axiom help page . . . 6697
39.1.3 fortran code . . . 6699
39.1.4 lisp code . . . 6700
39.2 zgetc2 . . . 6703
39.2.1 Axiom unit tests . . . 6703
39.2.2 Axiom help page . . . 6703
39.2.3 fortran code . . . 6705
39.2.4 lisp code . . . 6707
39.3 zlange . . . 6709
39.3.1 Axiom unit tests . . . 6709
39.3.2 Axiom help page . . . 6710
39.3.3 fortran code . . . 6711
39.3.4 lisp code . . . 6713
39.4 zlaqge . . . 6713
39.4.1 Axiom unit tests . . . 6713
39.4.2 Axiom help page . . . 6714
39.4.3 fortran code . . . 6716
39.4.4 lisp code . . . 6718
39.5 ztgex2 . . . 6720
39.5.1 Axiom unit tests . . . 6720
39.5.2 Axiom help page . . . 6720
39.5.3 fortran code . . . 6722
39.5.4 lisp code . . . 6726

40 LAPACK - General Band Matrix, Linear Solve, Double 6733
40.1 dgbsv . . . 6733
40.1.1 Axiom unit tests . . . 6733
40.1.2 Axiom help page . . . 6733
40.1.3 fortran code . . . 6735
40.1.4 lisp code . . . 6737
40.2 dgbsvx . . . 6738
40.2.1 Axiom unit tests . . . 6738
40.2.2 Axiom help page . . . 6739
40.2.3 fortran code . . . 6744
40.2.4 lisp code . . . 6749

40.3 dgbsvxx . . . 6759
40.3.1 Axiom unit tests . . . 6759
40.3.2 Axiom help page [?] . . . 6760
40.3.3 fortran code . . . 6768
40.3.4 lisp code . . . 6773

41 LAPACK - General Band Matrix, Linear Solve, Real 6783
41.1 sgbsv . . . 6783
41.1.1 Axiom unit tests . . . 6783
41.1.2 Axiom help page . . . 6783
41.1.3 fortran code . . . 6785
41.1.4 lisp code . . . 6787
41.2 sgbsvx . . . 6788
41.2.1 Axiom unit tests . . . 6788
41.2.2 Axiom help page . . . 6789
41.2.3 fortran code . . . 6794
41.2.4 lisp code . . . 6799
41.3 sgbsvxx . . . 6809
41.3.1 Axiom unit tests . . . 6809
41.3.2 Axiom help page [?] . . . 6810
41.3.3 fortran code . . . 6818
41.3.4 lisp code . . . 6823

42 LAPACK - General Band Matrix, Linear Solve, Complex 6833
42.1 cgbsv . . . 6833
42.1.1 Axiom unit tests . . . 6833
42.1.2 Axiom help page . . . 6833
42.1.3 fortran code . . . 6835
42.1.4 lisp code . . . 6837
42.2 cgbsvx . . . 6838
42.2.1 Axiom unit tests . . . 6838
42.2.2 Axiom help page . . . 6839
42.2.3 fortran code . . . 6844
42.2.4 lisp code . . . 6849
42.3 cgbsvxx . . . 6859
42.3.1 Axiom unit tests . . . 6859
42.3.2 Axiom help page . . . 6860
42.3.3 fortran code . . . 6868
42.3.4 lisp code . . . 6873

43 LAPACK - General Band Matrix, Linear Solve, Complex16 6883
43.1 zgbsv . . . 6883
43.1.1 Axiom unit tests . . . 6883
43.1.2 Axiom help page . . . 6883
43.1.3 fortran code . . . 6886
43.1.4 lisp code . . . 6887

43.2 zgbsvx . . . 6888
43.2.1 Axiom unit tests . . . 6888
43.2.2 Axiom help page . . . 6889
43.2.3 fortran code . . . 6894
43.2.4 lisp code . . . 6899
43.3 zgbsvxx . . . 6910
43.3.1 Axiom unit tests . . . 6910
43.3.2 Axiom help page [**?**] . . . 6910
43.3.3 fortran code . . . 6918
43.3.4 lisp code . . . 6923

44 LAPACK - General Band Matrix, Comp. Routines, Double 6933
44.1 dgbbrd . . . 6933
44.1.1 Axiom unit tests . . . 6933
44.1.2 Axiom help page . . . 6933
44.1.3 fortran code . . . 6936
44.1.4 lisp code . . . 6943
44.2 dgbcon . . . 6956
44.2.1 Axiom unit tests . . . 6956
44.2.2 Axiom help page . . . 6956
44.2.3 fortran code . . . 6958
44.2.4 lisp code . . . 6961
44.3 dgbequ . . . 6966
44.3.1 Axiom unit tests . . . 6966
44.3.2 Axiom help page . . . 6966
44.3.3 fortran code . . . 6968
44.3.4 lisp code . . . 6972
44.4 dgbequb . . . 6975
44.4.1 Axiom unit tests . . . 6975
44.4.2 Axiom help page . . . 6976
44.4.3 fortran code . . . 6978
44.4.4 lisp code . . . 6981
44.5 dgbrfs . . . 6985
44.5.1 Axiom unit tests . . . 6985
44.5.2 Axiom help page . . . 6986
44.5.3 fortran code . . . 6988
44.5.4 lisp code . . . 6993
44.6 dgbrfsx . . . 7002
44.6.1 Axiom unit tests . . . 7002
44.6.2 Axiom help page [**?**] . . . 7002
44.6.3 fortran code . . . 7008
44.6.4 lisp code . . . 7015
44.7 dgbtf2 . . . 7015
44.7.1 Axiom unit tests . . . 7015
44.7.2 Axiom help page . . . 7015
44.7.3 fortran code . . . 7017

44.7.4 lisp code . . . 7020
44.8 dgbtrf . . . 7023
44.8.1 Axiom unit tests . . . 7023
44.8.2 Axiom help page . . . 7023
44.8.3 fortran code . . . 7025
44.8.4 lisp code . . . 7032
44.9 dgbtrs . . . 7044
44.9.1 Axiom unit tests . . . 7044
44.9.2 Axiom help page . . . 7044
44.9.3 fortran code . . . 7046
44.9.4 lisp code . . . 7048
44.10 dggbak . . . 7052
44.10.1 Axiom unit tests . . . 7052
44.10.2 Axiom help page . . . 7053
44.10.3 fortran code . . . 7054
44.10.4 lisp code . . . 7057
44.11 dggbal . . . 7063
44.11.1 Axiom unit tests . . . 7063
44.11.2 Axiom help page . . . 7063
44.11.3 fortran code . . . 7065
44.11.4 lisp code . . . 7073
44.12 dla_gbamv . . . 7087
44.12.1 Axiom unit tests . . . 7087
44.12.2 Axiom help page . . . 7088
44.12.3 fortran code . . . 7090
44.12.4 lisp code . . . 7095
44.13 dla_gbrcond . . . 7101
44.13.1 Axiom unit tests . . . 7101
44.13.2 Axiom help page . . . 7102
44.13.3 fortran code . . . 7104
44.13.4 lisp code . . . 7108
44.14 dla_gbrfsx_extended . . . 7115
44.14.1 Axiom unit tests . . . 7115
44.14.2 Axiom help page [**?**] . . . 7115
44.14.3 fortran code . . . 7121
44.14.4 lisp code . . . 7127
44.15 dla_gbrpvgrw . . . 7135
44.15.1 Axiom unit tests . . . 7135
44.15.2 Axiom help page . . . 7135
44.15.3 fortran code . . . 7136
44.15.4 lisp code . . . 7137
44.16 dorgbr . . . 7139
44.16.1 Axiom unit tests . . . 7139
44.16.2 Axiom help page . . . 7139
44.16.3 fortran code . . . 7142
44.16.4 lisp code . . . 7145

45 LAPACK - General Band Matrix, Comp. Routines, Real 7147
45.1 sgbbrd . . . 7147
45.1.1 Axiom unit tests . . . 7147
45.1.2 Axiom help page . . . 7147
45.1.3 fortran code . . . 7150
45.1.4 lisp code . . . 7157
45.2 sgbcon . . . 7170
45.2.1 Axiom unit tests . . . 7170
45.2.2 Axiom help page . . . 7170
45.2.3 fortran code . . . 7172
45.2.4 lisp code . . . 7175
45.3 sgbequ . . . 7180
45.3.1 Axiom unit tests . . . 7180
45.3.2 Axiom help page . . . 7180
45.3.3 fortran code . . . 7182
45.3.4 lisp code . . . 7186
45.4 sgbequb . . . 7189
45.4.1 Axiom unit tests . . . 7189
45.4.2 Axiom help page . . . 7190
45.4.3 fortran code . . . 7192
45.4.4 lisp code . . . 7195
45.5 sgbrfs . . . 7199
45.5.1 Axiom unit tests . . . 7199
45.5.2 Axiom help page . . . 7200
45.5.3 fortran code . . . 7202
45.5.4 lisp code . . . 7207
45.6 sgbrfsx . . . 7215
45.6.1 Axiom unit tests . . . 7215
45.6.2 Axiom help page [**?**] . . . 7216
45.6.3 fortran code . . . 7222
45.6.4 lisp code . . . 7228
45.7 sgbtf2 . . . 7229
45.7.1 Axiom unit tests . . . 7229
45.7.2 Axiom help page . . . 7229
45.7.3 fortran code . . . 7231
45.7.4 lisp code . . . 7233
45.8 sgbtrf . . . 7236
45.8.1 Axiom unit tests . . . 7236
45.8.2 Axiom help page . . . 7237
45.8.3 fortran code . . . 7239
45.8.4 lisp code . . . 7246
45.9 sgbtrs . . . 7258
45.9.1 Axiom unit tests . . . 7258
45.9.2 Axiom help page . . . 7258
45.9.3 fortran code . . . 7260
45.9.4 lisp code . . . 7262

45.10sggbak 7266
45.10.1 Axiom unit tests 7266
45.10.2 Axiom help page 7266
45.10.3 fortran code 7268
45.10.4 lisp code 7271
45.11sggbal 7277
45.11.1 Axiom unit tests 7277
45.11.2 Axiom help page 7277
45.11.3 fortran code 7279
45.11.4 lisp code 7286
45.12sla_gbamv 7301
45.12.1 Axiom unit tests 7301
45.12.2 Axiom help page 7302
45.12.3 fortran code 7304
45.12.4 lisp code 7308
45.13sla_gbrcond 7315
45.13.1 Axiom unit tests 7315
45.13.2 Axiom help page 7316
45.13.3 fortran code 7318
45.13.4 lisp code 7321
45.14sla_gbrfsx_extended 7329
45.14.1 Axiom unit tests 7329
45.14.2 Axiom help page [**?**] 7329
45.14.3 fortran code 7335
45.14.4 lisp code 7341
45.15sla_gbrpvgrw 7348
45.15.1 Axiom unit tests 7348
45.15.2 Axiom help page 7349
45.15.3 fortran code 7350
45.15.4 lisp code 7351
45.16sorgbr 7353
45.16.1 Axiom unit tests 7353
45.16.2 Axiom help page 7353
45.16.3 fortran code 7355
45.16.4 lisp code 7359

46 LAPACK - General Band Matrix, Comp. Routines, Complex 7365
46.1 cgbbrd 7365
46.1.1 Axiom unit tests 7365
46.1.2 Axiom help page 7365
46.1.3 fortran code 7368
46.1.4 lisp code 7375
46.2 cgbcon 7375
46.2.1 Axiom unit tests 7375
46.2.2 Axiom help page 7376
46.2.3 fortran code 7377

46.2.4 lisp code . . . 7381
46.3 cgbequ . . . 7386
46.3.1 Axiom unit tests . . . 7386
46.3.2 Axiom help page . . . 7386
46.3.3 fortran code . . . 7388
46.3.4 lisp code . . . 7391
46.4 cgbequb . . . 7395
46.4.1 Axiom unit tests . . . 7395
46.4.2 Axiom help page . . . 7396
46.4.3 fortran code . . . 7398
46.4.4 lisp code . . . 7401
46.5 cgbrfs . . . 7406
46.5.1 Axiom unit tests . . . 7406
46.5.2 Axiom help page . . . 7406
46.5.3 fortran code . . . 7409
46.5.4 lisp code . . . 7414
46.6 cgbrfsx . . . 7422
46.6.1 Axiom unit tests . . . 7422
46.6.2 Axiom help page . . . 7422
46.6.3 fortran code . . . 7429
46.6.4 lisp code . . . 7435
46.7 cgbtf2 . . . 7435
46.7.1 Axiom unit tests . . . 7435
46.7.2 Axiom help page . . . 7436
46.7.3 fortran code . . . 7438
46.7.4 lisp code . . . 7440
46.8 cgbtrf . . . 7443
46.8.1 Axiom unit tests . . . 7443
46.8.2 Axiom help page . . . 7444
46.8.3 fortran code . . . 7445
46.8.4 lisp code . . . 7452
46.9 cgbtrs . . . 7465
46.9.1 Axiom unit tests . . . 7465
46.9.2 Axiom help page . . . 7465
46.9.3 fortran code . . . 7467
46.9.4 lisp code . . . 7470
46.10 cggbak . . . 7475
46.10.1 Axiom unit tests . . . 7475
46.10.2 Axiom help page . . . 7476
46.10.3 fortran code . . . 7477
46.10.4 lisp code . . . 7480
46.11 cggbal . . . 7486
46.11.1 Axiom unit tests . . . 7486
46.11.2 Axiom help page . . . 7486
46.11.3 fortran code . . . 7488
46.11.4 lisp code . . . 7496

46.12cla_gbamv . . . 7512
46.12.1 Axiom unit tests . . . 7512
46.12.2 Axiom help page . . . 7512
46.12.3 fortran code . . . 7515
46.12.4 lisp code . . . 7519
46.13cla_gbrcond_c . . . 7526
46.13.1 Axiom unit tests . . . 7526
46.13.2 Axiom help page . . . 7527
46.13.3 fortran code . . . 7529
46.13.4 lisp code . . . 7532
46.14cla_gbrcond_x . . . 7539
46.14.1 Axiom unit tests . . . 7539
46.14.2 Axiom help page . . . 7539
46.14.3 fortran code . . . 7541
46.14.4 lisp code . . . 7544
46.15cla_gbrfsx_extended . . . 7549
46.15.1 Axiom unit tests . . . 7549
46.15.2 Axiom help page [**?**] . . . 7550
46.15.3 fortran code . . . 7556
46.15.4 lisp code . . . 7562
46.16cla_gbrpvgrw . . . 7570
46.16.1 Axiom unit tests . . . 7570
46.16.2 Axiom help page . . . 7570
46.16.3 fortran code . . . 7571
46.16.4 lisp code . . . 7573
46.17cungbr . . . 7574
46.17.1 Axiom unit tests . . . 7574
46.17.2 Axiom help page . . . 7575
46.17.3 fortran code . . . 7577
46.17.4 lisp code . . . 7580

47 LAPACK - General Band Matrix, Comp. Routines, Complex16 7587
47.1 zgbbrd . . . 7587
47.1.1 Axiom unit tests . . . 7587
47.1.2 Axiom help page . . . 7587
47.1.3 fortran code . . . 7590
47.1.4 lisp code . . . 7597
47.2 zgbcon . . . 7612
47.2.1 Axiom unit tests . . . 7612
47.2.2 Axiom help page . . . 7612
47.2.3 fortran code . . . 7614
47.2.4 lisp code . . . 7617
47.3 zgbequ . . . 7622
47.3.1 Axiom unit tests . . . 7622
47.3.2 Axiom help page . . . 7622
47.3.3 fortran code . . . 7624

47.3.4 lisp code . . . 7628
47.4 zgbequb . . . 7632
47.4.1 Axiom unit tests . . . 7632
47.4.2 Axiom help page . . . 7632
47.4.3 fortran code . . . 7634
47.4.4 lisp code . . . 7638
47.5 zgbrfs . . . 7642
47.5.1 Axiom unit tests . . . 7642
47.5.2 Axiom help page . . . 7643
47.5.3 fortran code . . . 7645
47.5.4 lisp code . . . 7650
47.6 zgbrfsx . . . 7659
47.6.1 Axiom unit tests . . . 7659
47.6.2 Axiom help page [**?**] . . . 7659
47.6.3 fortran code . . . 7665
47.6.4 lisp code . . . 7672
47.7 zgbtf2 . . . 7672
47.7.1 Axiom unit tests . . . 7672
47.7.2 Axiom help page . . . 7672
47.7.3 fortran code . . . 7674
47.7.4 lisp code . . . 7677
47.8 zgbtrf . . . 7680
47.8.1 Axiom unit tests . . . 7680
47.8.2 Axiom help page . . . 7680
47.8.3 fortran code . . . 7682
47.8.4 lisp code . . . 7689
47.9 zgbtrs . . . 7701
47.9.1 Axiom unit tests . . . 7701
47.9.2 Axiom help page . . . 7701
47.9.3 fortran code . . . 7703
47.9.4 lisp code . . . 7706
47.10 zggbak . . . 7712
47.10.1 Axiom unit tests . . . 7712
47.10.2 Axiom help page . . . 7712
47.10.3 fortran code . . . 7714
47.10.4 lisp code . . . 7717
47.11 zggbal . . . 7722
47.11.1 Axiom unit tests . . . 7722
47.11.2 Axiom help page . . . 7722
47.11.3 fortran code . . . 7725
47.11.4 lisp code . . . 7732
47.12 zla_gbamv . . . 7748
47.12.1 Axiom unit tests . . . 7748
47.12.2 Axiom help page . . . 7748
47.12.3 fortran code . . . 7751
47.12.4 lisp code . . . 7755

47.13zla_gbrcond_c . . . 7763
47.13.1 Axiom unit tests . . . 7763
47.13.2 Axiom help page . . . 7763
47.13.3 fortran code . . . 7765
47.13.4 lisp code . . . 7769
47.14zla_gbrcond_x . . . 7775
47.14.1 Axiom unit tests . . . 7775
47.14.2 Axiom help page . . . 7775
47.14.3 fortran code . . . 7777
47.14.4 lisp code . . . 7781
47.15zla_gbrfsx_extended . . . 7786
47.15.1 Axiom unit tests . . . 7786
47.15.2 Axiom help page [**?**] . . . 7786
47.15.3 fortran code . . . 7792
47.15.4 lisp code . . . 7798
47.16zla_gbrpvgrw . . . 7806
47.16.1 Axiom unit tests . . . 7806
47.16.2 Axiom help page . . . 7806
47.16.3 fortran code . . . 7808
47.16.4 lisp code . . . 7809
47.17zungbr . . . 7811
47.17.1 Axiom unit tests . . . 7811
47.17.2 Axiom help page . . . 7811
47.17.3 fortran code . . . 7813
47.17.4 lisp code . . . 7817

48 LAPACK - General Band Matrix, Auxilliary Routines, Double 7823
48.1 dlangb . . . 7823
48.1.1 Axiom unit tests . . . 7823
48.1.2 Axiom help page . . . 7823
48.1.3 fortran code . . . 7825
48.1.4 lisp code . . . 7827
48.2 dlaqgb . . . 7831
48.2.1 Axiom unit tests . . . 7831
48.2.2 Axiom help page . . . 7832
48.2.3 fortran code . . . 7834
48.2.4 lisp code . . . 7836

49 LAPACK - General Band Matrix, Auxilliary Routines, Real 7839
49.1 slangb . . . 7839
49.1.1 Axiom unit tests . . . 7839
49.1.2 Axiom help page . . . 7839
49.1.3 fortran code . . . 7841
49.1.4 lisp code . . . 7843
49.2 slaqgb . . . 7847
49.2.1 Axiom unit tests . . . 7847

49.2.2 Axiom help page . . . 7847
49.2.3 fortran code . . . 7849
49.2.4 lisp code . . . 7851

50 LAPACK - General Band Matrix, Auxilliary Routines, Complex 7855
50.1 clangb . . . 7855
50.1.1 Axiom unit tests . . . 7855
50.1.2 Axiom help page . . . 7855
50.1.3 fortran code . . . 7857
50.1.4 lisp code . . . 7859
50.2 claqgb . . . 7863
50.2.1 Axiom unit tests . . . 7863
50.2.2 Axiom help page . . . 7864
50.2.3 fortran code . . . 7866
50.2.4 lisp code . . . 7868

51 LAPACK - General Band Matrix, Auxilliary Routines, Complex16 7871
51.1 zlangb . . . 7871
51.1.1 Axiom unit tests . . . 7871
51.1.2 Axiom help page . . . 7871
51.1.3 fortran code . . . 7873
51.1.4 lisp code . . . 7875
51.2 zlaqgb . . . 7879
51.2.1 Axiom unit tests . . . 7879
51.2.2 Axiom help page . . . 7880
51.2.3 fortran code . . . 7882
51.2.4 lisp code . . . 7884

52 LAPACK - Symmetric Matrix, Linear Solve, Double 7887
52.1 dsysv . . . 7887
52.1.1 Axiom unit tests . . . 7887
52.1.2 Axiom help page . . . 7887
52.1.3 fortran code . . . 7890
52.1.4 lisp code . . . 7892
52.2 dsysv_rook . . . 7894
52.2.1 Axiom unit tests . . . 7894
52.2.2 Axiom help page . . . 7894
52.2.3 fortran code . . . 7897
52.2.4 lisp code . . . 7899
52.3 dsysvx . . . 7901
52.3.1 Axiom unit tests . . . 7901
52.3.2 Axiom help page . . . 7902
52.3.3 fortran code . . . 7906
52.3.4 lisp code . . . 7908

53 LAPACK - Symmetric Matrix, Linear Solve, Real 7913
53.1 ssysv . . . 7913
53.1.1 Axiom unit tests . . . 7913
53.1.2 Axiom help page . . . 7913
53.1.3 fortran code . . . 7916
53.1.4 lisp code . . . 7918
53.2 ssysv_rook . . . 7920
53.2.1 Axiom unit tests . . . 7920
53.2.2 Axiom help page . . . 7920
53.2.3 fortran code . . . 7923
53.2.4 lisp code . . . 7925
53.3 ssysvx . . . 7927
53.3.1 Axiom unit tests . . . 7927
53.3.2 Axiom help page . . . 7928
53.3.3 fortran code . . . 7931
53.3.4 lisp code . . . 7934

54 LAPACK - Symmetric Matrix, Linear Solve, Complex 7939
54.1 csysv . . . 7939
54.1.1 Axiom unit tests . . . 7939
54.1.2 Axiom help page . . . 7939
54.1.3 fortran code . . . 7942
54.1.4 lisp code . . . 7944
54.2 csysv_rook . . . 7946
54.2.1 Axiom unit tests . . . 7946
54.2.2 Axiom help page . . . 7947
54.2.3 fortran code . . . 7949
54.2.4 lisp code . . . 7951
54.3 csysvx . . . 7953
54.3.1 Axiom unit tests . . . 7953
54.3.2 Axiom help page . . . 7954
54.3.3 fortran code . . . 7958
54.3.4 lisp code . . . 7960
54.4 csysvxx . . . 7964
54.4.1 Axiom unit tests . . . 7964
54.4.2 Axiom help page . . . 7965
54.4.3 fortran code . . . 7972
54.4.4 lisp code . . . 7976

55 LAPACK - Symmetric Matrix, Linear Solve, Complex16 7983
55.1 zsysv . . . 7983
55.1.1 Axiom unit tests . . . 7983
55.1.2 Axiom help page . . . 7983
55.1.3 fortran code . . . 7986
55.1.4 lisp code . . . 7988
55.2 zsysv_rook . . . 7990

55.2.1 Axiom unit tests . . . 7990
55.2.2 Axiom help page . . . 7991
55.2.3 fortran code . . . 7993
55.2.4 lisp code . . . 7995
55.3 zsysvx . . . 7997
55.3.1 Axiom unit tests . . . 7997
55.3.2 Axiom help page . . . 7998
55.3.3 fortran code . . . 8002
55.3.4 lisp code . . . 8004
55.4 zsysvxx . . . 8008
55.4.1 Axiom unit tests . . . 8008
55.4.2 Axiom help page [**?**] . . . 8009
55.4.3 fortran code . . . 8016
55.4.4 lisp code . . . 8020

56 LAPACK - Symmetric Matrix, Eigenvalue, Double 8027
56.1 dsyev . . . 8027
56.1.1 Axiom unit tests . . . 8027
56.1.2 Axiom help page . . . 8027
56.1.3 fortran code . . . 8029
56.1.4 lisp code . . . 8032
56.2 dsyevd . . . 8036
56.2.1 Axiom unit tests . . . 8036
56.2.2 Axiom help page . . . 8037
56.2.3 fortran code . . . 8039
56.2.4 lisp code . . . 8042
56.3 dsyevr . . . 8047
56.3.1 Axiom unit tests . . . 8047
56.3.2 Axiom help page . . . 8048
56.3.3 fortran code . . . 8052
56.3.4 lisp code . . . 8059
56.4 dsyevx . . . 8069
56.4.1 Axiom unit tests . . . 8069
56.4.2 Axiom help page . . . 8069
56.4.3 fortran code . . . 8072
56.4.4 lisp code . . . 8078
56.5 dsygv . . . 8088
56.5.1 Axiom unit tests . . . 8088
56.5.2 Axiom help page . . . 8089
56.5.3 fortran code . . . 8091
56.5.4 lisp code . . . 8094
56.6 dsygvd . . . 8097
56.6.1 Axiom unit tests . . . 8097
56.6.2 Axiom help page . . . 8098
56.6.3 fortran code . . . 8101
56.6.4 lisp code . . . 8104

56.7 dsygvx 8108
56.7.1 Axiom unit tests 8108
56.7.2 Axiom help page 8108
56.7.3 fortran code 8112
56.7.4 lisp code 8115

57 LAPACK - Symmetric Matrix, Eigenvalue, Real 8121
57.1 ssyev 8121
57.1.1 Axiom unit tests 8121
57.1.2 Axiom help page 8121
57.1.3 fortran code 8123
57.1.4 lisp code 8126
57.2 ssyevd 8130
57.2.1 Axiom unit tests 8130
57.2.2 Axiom help page 8131
57.2.3 fortran code 8133
57.2.4 lisp code 8136
57.3 ssyevr 8141
57.3.1 Axiom unit tests 8141
57.3.2 Axiom help page 8141
57.3.3 fortran code 8146
57.3.4 lisp code 8153
57.4 ssyevx 8163
57.4.1 Axiom unit tests 8163
57.4.2 Axiom help page 8163
57.4.3 fortran code 8166
57.4.4 lisp code 8172
57.5 ssygv 8182
57.5.1 Axiom unit tests 8182
57.5.2 Axiom help page 8182
57.5.3 fortran code 8184
57.5.4 lisp code 8187
57.6 ssygvd 8191
57.6.1 Axiom unit tests 8191
57.6.2 Axiom help page 8191
57.6.3 fortran code 8194
57.6.4 lisp code 8197
57.7 ssygvx 8201
57.7.1 Axiom unit tests 8201
57.7.2 Axiom help page 8201
57.7.3 fortran code 8205
57.7.4 lisp code 8208

58 LAPACK - Symmetric Matrix, Comp. Routines, Double 8215
58.1 dla_syamv . . . 8215
58.1.1 Axiom unit tests . . . 8215
58.1.2 Axiom help page . . . 8215
58.1.3 fortran code . . . 8217
58.1.4 lisp code . . . 8222
58.2 dla_syrcond . . . 8230
58.2.1 Axiom unit tests . . . 8230
58.2.2 Axiom help page . . . 8230
58.2.3 fortran code . . . 8232
58.2.4 lisp code . . . 8236
58.3 dla_syrfsx_extended . . . 8242
58.3.1 Axiom unit tests . . . 8242
58.3.2 Axiom help page [**?**] . . . 8243
58.3.3 fortran code . . . 8248
58.3.4 lisp code . . . 8254
58.4 dla_syrpvgrw . . . 8262
58.4.1 Axiom unit tests . . . 8262
58.4.2 Axiom help page . . . 8262
58.4.3 fortran code . . . 8264
58.4.4 lisp code . . . 8268
58.5 dlasyf . . . 8274
58.5.1 Axiom unit tests . . . 8274
58.5.2 Axiom help page . . . 8275
58.5.3 fortran code . . . 8277
58.5.4 lisp code . . . 8289
58.6 dlasyf_rook . . . 8306
58.6.1 Axiom unit tests . . . 8306
58.6.2 Axiom help page . . . 8306
58.6.3 fortran code . . . 8308
58.6.4 lisp code . . . 8322
58.7 dsycon . . . 8342
58.7.1 Axiom unit tests . . . 8342
58.7.2 Axiom help page . . . 8343
58.7.3 fortran code . . . 8344
58.7.4 lisp code . . . 8347
58.8 dsycon_rook . . . 8349
58.8.1 Axiom unit tests . . . 8349
58.8.2 Axiom help page . . . 8349
58.8.3 fortran code . . . 8351
58.8.4 lisp code . . . 8353
58.9 dsyconv . . . 8356
58.9.1 Axiom unit tests . . . 8356
58.9.2 Axiom help page . . . 8356
58.9.3 fortran code . . . 8357
58.9.4 lisp code . . . 8362

58.10dsyequb 8369
58.10.1 Axiom unit tests 8369
58.10.2 Axiom help page 8370
58.10.3 fortran code 8371
58.10.4 lisp code 8375
58.11dsygs2 8384
58.11.1 Axiom unit tests 8384
58.11.2 Axiom help page 8384
58.11.3 fortran code 8386
58.11.4 lisp code 8389
58.12dsygst 8396
58.12.1 Axiom unit tests 8396
58.12.2 Axiom help page 8396
58.12.3 fortran code 8398
58.12.4 lisp code 8402
58.13dsyrfs 8413
58.13.1 Axiom unit tests 8413
58.13.2 Axiom help page 8413
58.13.3 fortran code 8416
58.13.4 lisp code 8421
58.14dsyrfsx 8429
58.14.1 Axiom unit tests 8429
58.14.2 Axiom help page [**?**] 8429
58.14.3 fortran code 8435
58.14.4 lisp code 8441
58.15dsytd2 8441
58.15.1 Axiom unit tests 8441
58.15.2 Axiom help page 8441
58.15.3 fortran code 8444
58.15.4 lisp code 8447
58.16dsytf2 8451
58.16.1 Axiom unit tests 8451
58.16.2 Axiom help page 8452
58.16.3 fortran code 8454
58.16.4 lisp code 8462
58.17dsytf2_rook 8472
58.17.1 Axiom unit tests 8472
58.17.2 Axiom help page 8472
58.17.3 fortran code 8475
58.17.4 lisp code 8479
58.18dsytrd 8492
58.18.1 Axiom unit tests 8492
58.18.2 Axiom help page 8492
58.18.3 fortran code 8495
58.18.4 lisp code 8498
58.19dsytrf 8503

58.19.1 Axiom unit tests . . . 8503
58.19.2 Axiom help page . . . 8503
58.19.3 fortran code . . . 8506
58.19.4 lisp code . . . 8509
58.20 dsytrf_rook . . . 8513
58.20.1 Axiom unit tests . . . 8513
58.20.2 Axiom help page . . . 8514
58.20.3 fortran code . . . 8516
58.20.4 lisp code . . . 8520
58.21 dsytri . . . 8524
58.21.1 Axiom unit tests . . . 8524
58.21.2 Axiom help page . . . 8524
58.21.3 fortran code . . . 8526
58.21.4 lisp code . . . 8531
58.22 dsytri2 . . . 8540
58.22.1 Axiom unit tests . . . 8540
58.22.2 Axiom help page . . . 8540
58.22.3 fortran code . . . 8542
58.22.4 lisp code . . . 8544
58.23 dsytri2x . . . 8546
58.23.1 Axiom unit tests . . . 8546
58.23.2 Axiom help page . . . 8546
58.23.3 fortran code . . . 8547
58.23.4 lisp code . . . 8556
58.24 dsytri_rook . . . 8576
58.24.1 Axiom unit tests . . . 8576
58.24.2 Axiom help page . . . 8576
58.24.3 fortran code . . . 8578
58.24.4 lisp code . . . 8584
58.25 dsytrs . . . 8596
58.25.1 Axiom unit tests . . . 8596
58.25.2 Axiom help page . . . 8596
58.25.3 fortran code . . . 8597
58.25.4 lisp code . . . 8604
58.26 dsytrs2 . . . 8614
58.26.1 Axiom unit tests . . . 8614
58.26.2 Axiom help page . . . 8614
58.26.3 fortran code . . . 8616
58.26.4 lisp code . . . 8620
58.27 dsytrs_rook . . . 8628
58.27.1 Axiom unit tests . . . 8628
58.27.2 Axiom help page . . . 8629
58.27.3 fortran code . . . 8630
58.27.4 lisp code . . . 8637
58.28 dtgsyl . . . 8649
58.28.1 Axiom unit tests . . . 8649

58.28.2 Axiom help page . . . 8649
58.28.3 fortran code . . . 8653
58.28.4 lisp code . . . 8660
58.29 dtrsyl . . . 8678
58.29.1 Axiom unit tests . . . 8678
58.29.2 Axiom help page . . . 8678
58.29.3 fortran code . . . 8680
58.29.4 lisp code . . . 8696

59 LAPACK - Symmetric Matrix, Comp. Routines, Real 8747
59.1 sla_syamv . . . 8747
59.1.1 Axiom unit tests . . . 8747
59.1.2 Axiom help page . . . 8747
59.1.3 fortran code . . . 8749
59.1.4 lisp code . . . 8754
59.2 sla_syrcond . . . 8761
59.2.1 Axiom unit tests . . . 8761
59.2.2 Axiom help page . . . 8762
59.2.3 fortran code . . . 8764
59.2.4 lisp code . . . 8767
59.3 sla_syrfsx_extended . . . 8774
59.3.1 Axiom unit tests . . . 8774
59.3.2 Axiom help page [**?**] . . . 8774
59.3.3 fortran code . . . 8780
59.3.4 lisp code . . . 8786
59.4 sla_syrpvgrw . . . 8794
59.4.1 Axiom unit tests . . . 8794
59.4.2 Axiom help page . . . 8794
59.4.3 fortran code . . . 8796
59.4.4 lisp code . . . 8799
59.5 slasyf . . . 8806
59.5.1 Axiom unit tests . . . 8806
59.5.2 Axiom help page . . . 8807
59.5.3 fortran code . . . 8809
59.5.4 lisp code . . . 8821
59.6 slasyf_rook . . . 8837
59.6.1 Axiom unit tests . . . 8837
59.6.2 Axiom help page . . . 8838
59.6.3 fortran code . . . 8840
59.6.4 lisp code . . . 8853
59.7 ssycon . . . 8874
59.7.1 Axiom unit tests . . . 8874
59.7.2 Axiom help page . . . 8874
59.7.3 fortran code . . . 8876
59.7.4 lisp code . . . 8878
59.8 ssycon_rook . . . 8881

59.8.1 Axiom unit tests . . . 8881
59.8.2 Axiom help page . . . 8881
59.8.3 fortran code . . . 8883
59.8.4 lisp code . . . 8885
59.9 ssyconv . . . 8887
59.9.1 Axiom unit tests . . . 8887
59.9.2 Axiom help page . . . 8888
59.9.3 fortran code . . . 8889
59.9.4 lisp code . . . 8894
59.10ssyequb . . . 8901
59.10.1 Axiom unit tests . . . 8901
59.10.2 Axiom help page . . . 8901
59.10.3 fortran code . . . 8903
59.10.4 lisp code . . . 8907
59.11ssygs2 . . . 8915
59.11.1 Axiom unit tests . . . 8915
59.11.2 Axiom help page . . . 8916
59.11.3 fortran code . . . 8917
59.11.4 lisp code . . . 8921
59.12ssygst . . . 8928
59.12.1 Axiom unit tests . . . 8928
59.12.2 Axiom help page . . . 8928
59.12.3 fortran code . . . 8930
59.12.4 lisp code . . . 8933
59.13ssyrfs . . . 8945
59.13.1 Axiom unit tests . . . 8945
59.13.2 Axiom help page . . . 8945
59.13.3 fortran code . . . 8947
59.13.4 lisp code . . . 8952
59.14ssyrfsx . . . 8960
59.14.1 Axiom unit tests . . . 8960
59.14.2 Axiom help page [**?**] . . . 8961
59.14.3 fortran code . . . 8966
59.14.4 lisp code . . . 8972
59.15ssytd2 . . . 8972
59.15.1 Axiom unit tests . . . 8972
59.15.2 Axiom help page . . . 8973
59.15.3 fortran code . . . 8975
59.15.4 lisp code . . . 8978
59.16ssytf2 . . . 8983
59.16.1 Axiom unit tests . . . 8983
59.16.2 Axiom help page . . . 8983
59.16.3 fortran code . . . 8986
59.16.4 lisp code . . . 8994
59.17ssytf2_rook . . . 9003
59.17.1 Axiom unit tests . . . 9003

59.17.2 Axiom help page . . . 9004
59.17.3 fortran code . . . 9006
59.17.4 lisp code . . . 9018
59.18 ssytrd . . . 9031
59.18.1 Axiom unit tests . . . 9031
59.18.2 Axiom help page . . . 9031
59.18.3 fortran code . . . 9034
59.18.4 lisp code . . . 9038
59.19 ssytrf . . . 9042
59.19.1 Axiom unit tests . . . 9042
59.19.2 Axiom help page . . . 9043
59.19.3 fortran code . . . 9045
59.19.4 lisp code . . . 9049
59.20 ssytrf_rook . . . 9053
59.20.1 Axiom unit tests . . . 9053
59.20.2 Axiom help page . . . 9053
59.20.3 fortran code . . . 9056
59.20.4 lisp code . . . 9059
59.21 ssytri . . . 9063
59.21.1 Axiom unit tests . . . 9063
59.21.2 Axiom help page . . . 9063
59.21.3 fortran code . . . 9065
59.21.4 lisp code . . . 9070
59.22 ssytri2 . . . 9079
59.22.1 Axiom unit tests . . . 9079
59.22.2 Axiom help page . . . 9080
59.22.3 fortran code . . . 9081
59.22.4 lisp code . . . 9083
59.23 ssytri2x . . . 9085
59.23.1 Axiom unit tests . . . 9085
59.23.2 Axiom help page . . . 9085
59.23.3 fortran code . . . 9087
59.23.4 lisp code . . . 9095
59.24 ssytri_rook . . . 9115
59.24.1 Axiom unit tests . . . 9115
59.24.2 Axiom help page . . . 9115
59.24.3 fortran code . . . 9117
59.24.4 lisp code . . . 9123
59.25 ssytrs . . . 9135
59.25.1 Axiom unit tests . . . 9135
59.25.2 Axiom help page . . . 9135
59.25.3 fortran code . . . 9137
59.25.4 lisp code . . . 9143
59.26 ssytrs2 . . . 9153
59.26.1 Axiom unit tests . . . 9153
59.26.2 Axiom help page . . . 9153

59.26.3 fortran code . . . 9155
59.26.4 lisp code . . . 9159
59.27 ssytrs_rook . . . 9168
59.27.1 Axiom unit tests . . . 9168
59.27.2 Axiom help page . . . 9168
59.27.3 fortran code . . . 9169
59.27.4 lisp code . . . 9176
59.28 stgsyl . . . 9188
59.28.1 Axiom unit tests . . . 9188
59.28.2 Axiom help page . . . 9188
59.28.3 fortran code . . . 9192
59.28.4 lisp code . . . 9199
59.29 strsyl . . . 9215
59.29.1 Axiom unit tests . . . 9215
59.29.2 Axiom help page . . . 9215
59.29.3 fortran code . . . 9217
59.29.4 lisp code . . . 9233

60 LAPACK - Symmetric Matrix, Comp. Routines, Complex 9283
60.1 cla_syamv . . . 9283
60.1.1 Axiom unit tests . . . 9283
60.1.2 Axiom help page . . . 9283
60.1.3 fortran code . . . 9285
60.1.4 lisp code . . . 9290
60.2 cla_syrcond_c . . . 9298
60.2.1 Axiom unit tests . . . 9298
60.2.2 Axiom help page . . . 9298
60.2.3 fortran code . . . 9300
60.2.4 lisp code . . . 9304
60.3 cla_syrcond_x . . . 9310
60.3.1 Axiom unit tests . . . 9310
60.3.2 Axiom help page . . . 9310
60.3.3 fortran code . . . 9312
60.3.4 lisp code . . . 9315
60.4 cla_syrfsx_extended . . . 9320
60.4.1 Axiom unit tests . . . 9320
60.4.2 Axiom help page [**?**] . . . 9320
60.4.3 fortran code . . . 9326
60.4.4 lisp code . . . 9332
60.5 cla_syrpvgrw . . . 9340
60.5.1 Axiom unit tests . . . 9340
60.5.2 Axiom help page . . . 9340
60.5.3 fortran code . . . 9342
60.5.4 lisp code . . . 9346
60.6 clasyf . . . 9353
60.6.1 Axiom unit tests . . . 9353

60.6.2 Axiom help page . . . 9353
60.6.3 fortran code . . . 9355
60.6.4 lisp code . . . 9368
60.7 clasyf_rook . . . 9385
60.7.1 Axiom unit tests . . . 9385
60.7.2 Axiom help page . . . 9385
60.7.3 fortran code . . . 9388
60.7.4 lisp code . . . 9401
60.8 csycon . . . 9424
60.8.1 Axiom unit tests . . . 9424
60.8.2 Axiom help page . . . 9424
60.8.3 fortran code . . . 9426
60.8.4 lisp code . . . 9428
60.9 csycon_rook . . . 9430
60.9.1 Axiom unit tests . . . 9430
60.9.2 Axiom help page . . . 9431
60.9.3 fortran code . . . 9432
60.9.4 lisp code . . . 9435
60.10csyconv . . . 9437
60.10.1 Axiom unit tests . . . 9437
60.10.2 Axiom help page . . . 9437
60.10.3 fortran code . . . 9439
60.10.4 lisp code . . . 9444
60.11csyequb . . . 9451
60.11.1 Axiom unit tests . . . 9451
60.11.2 Axiom help page . . . 9451
60.11.3 fortran code . . . 9453
60.11.4 lisp code . . . 9457
60.12csyrfs . . . 9466
60.12.1 Axiom unit tests . . . 9466
60.12.2 Axiom help page . . . 9466
60.12.3 fortran code . . . 9469
60.12.4 lisp code . . . 9473
60.13csyrfsx . . . 9481
60.13.1 Axiom unit tests . . . 9481
60.13.2 Axiom help page [**?**] . . . 9482
60.13.3 fortran code . . . 9488
60.13.4 lisp code . . . 9493
60.14csytf2 . . . 9494
60.14.1 Axiom unit tests . . . 9494
60.14.2 Axiom help page . . . 9494
60.14.3 fortran code . . . 9496
60.14.4 lisp code . . . 9504
60.15csytf2_rook . . . 9515
60.15.1 Axiom unit tests . . . 9515
60.15.2 Axiom help page . . . 9516

60.15.3 fortran code . . . 9518
60.15.4 lisp code . . . 9530
60.16 csytrf . . . 9544
60.16.1 Axiom unit tests . . . 9544
60.16.2 Axiom help page . . . 9544
60.16.3 fortran code . . . 9547
60.16.4 lisp code . . . 9550
60.17 csytrf_rook . . . 9554
60.17.1 Axiom unit tests . . . 9554
60.17.2 Axiom help page . . . 9555
60.17.3 fortran code . . . 9557
60.17.4 lisp code . . . 9561
60.18 csytri . . . 9565
60.18.1 Axiom unit tests . . . 9565
60.18.2 Axiom help page . . . 9565
60.18.3 fortran code . . . 9567
60.18.4 lisp code . . . 9572
60.19 csytri2 . . . 9581
60.19.1 Axiom unit tests . . . 9581
60.19.2 Axiom help page . . . 9582
60.19.3 fortran code . . . 9583
60.19.4 lisp code . . . 9585
60.20 csytri2x . . . 9587
60.20.1 Axiom unit tests . . . 9587
60.20.2 Axiom help page . . . 9587
60.20.3 fortran code . . . 9589
60.20.4 lisp code . . . 9598
60.21 csytri_rook . . . 9617
60.21.1 Axiom unit tests . . . 9617
60.21.2 Axiom help page . . . 9618
60.21.3 fortran code . . . 9619
60.21.4 lisp code . . . 9625
60.22 csytrs . . . 9637
60.22.1 Axiom unit tests . . . 9637
60.22.2 Axiom help page . . . 9638
60.22.3 fortran code . . . 9639
60.22.4 lisp code . . . 9645
60.23 csytrs2 . . . 9656
60.23.1 Axiom unit tests . . . 9656
60.23.2 Axiom help page . . . 9656
60.23.3 fortran code . . . 9658
60.23.4 lisp code . . . 9662
60.24 csytrs_rook . . . 9670
60.24.1 Axiom unit tests . . . 9670
60.24.2 Axiom help page . . . 9671
60.24.3 fortran code . . . 9672

60.24.4 lisp code . . . 9679
60.25 ctgsyl . . . 9691
60.25.1 Axiom unit tests . . . 9691
60.25.2 Axiom help page . . . 9691
60.25.3 fortran code . . . 9695
60.25.4 lisp code . . . 9702
60.26 ctrsyl . . . 9718
60.26.1 Axiom unit tests . . . 9718
60.26.2 Axiom help page . . . 9718
60.26.3 fortran code . . . 9720
60.26.4 lisp code . . . 9726

61 LAPACK - Symmetric Matrix, Comp. Routines, Complex16 9737
61.1 zla_syamv . . . 9737
61.1.1 Axiom unit tests . . . 9737
61.1.2 Axiom help page . . . 9737
61.1.3 fortran code . . . 9739
61.1.4 lisp code . . . 9744
61.2 zla_syrcond_c . . . 9752
61.2.1 Axiom unit tests . . . 9752
61.2.2 Axiom help page . . . 9752
61.2.3 fortran code . . . 9754
61.2.4 lisp code . . . 9758
61.3 zla_syrcond_x . . . 9764
61.3.1 Axiom unit tests . . . 9764
61.3.2 Axiom help page . . . 9764
61.3.3 fortran code . . . 9766
61.3.4 lisp code . . . 9769
61.4 zla_syrfsx_extended . . . 9774
61.4.1 Axiom unit tests . . . 9774
61.4.2 Axiom help page [**?**] . . . 9774
61.4.3 fortran code . . . 9780
61.4.4 lisp code . . . 9786
61.5 zla_syrpvgrw . . . 9794
61.5.1 Axiom unit tests . . . 9794
61.5.2 Axiom help page . . . 9795
61.5.3 fortran code . . . 9796
61.5.4 lisp code . . . 9800
61.6 zlasyf . . . 9807
61.6.1 Axiom unit tests . . . 9807
61.6.2 Axiom help page . . . 9808
61.6.3 fortran code . . . 9810
61.6.4 lisp code . . . 9822
61.7 zlasyf_rook . . . 9822
61.7.1 Axiom unit tests . . . 9822
61.7.2 Axiom help page . . . 9823

61.7.3 fortran code . . . 9825
61.7.4 lisp code . . . 9838
61.8 zsycon . . . 9839
61.8.1 Axiom unit tests . . . 9839
61.8.2 Axiom help page . . . 9839
61.8.3 fortran code . . . 9841
61.8.4 lisp code . . . 9843
61.9 zsycon_rook . . . 9845
61.9.1 Axiom unit tests . . . 9845
61.9.2 Axiom help page . . . 9846
61.9.3 fortran code . . . 9847
61.9.4 lisp code . . . 9850
61.10 zsyconv . . . 9852
61.10.1 Axiom unit tests . . . 9852
61.10.2 Axiom help page . . . 9852
61.10.3 fortran code . . . 9854
61.10.4 lisp code . . . 9859
61.11 zsyequb . . . 9866
61.11.1 Axiom unit tests . . . 9866
61.11.2 Axiom help page . . . 9866
61.11.3 fortran code . . . 9868
61.11.4 lisp code . . . 9872
61.12 zsyrfs . . . 9881
61.12.1 Axiom unit tests . . . 9881
61.12.2 Axiom help page . . . 9881
61.12.3 fortran code . . . 9884
61.12.4 lisp code . . . 9889
61.13 zsyrfsx . . . 9897
61.13.1 Axiom unit tests . . . 9897
61.13.2 Axiom help page [**?**] . . . 9897
61.13.3 fortran code . . . 9903
61.13.4 lisp code . . . 9909
61.14 zsytf2 . . . 9909
61.14.1 Axiom unit tests . . . 9909
61.14.2 Axiom help page . . . 9909
61.14.3 fortran code . . . 9912
61.14.4 lisp code . . . 9920
61.15 zsytf2_rook . . . 9920
61.15.1 Axiom unit tests . . . 9920
61.15.2 Axiom help page . . . 9920
61.15.3 fortran code . . . 9923
61.15.4 lisp code . . . 9926
61.16 zsytrf . . . 9926
61.16.1 Axiom unit tests . . . 9926
61.16.2 Axiom help page . . . 9927
61.16.3 fortran code . . . 9929

61.16.4 lisp code . . . 9933
61.17 zsytrf_rook . . . 9937
61.17.1 Axiom unit tests . . . 9937
61.17.2 Axiom help page . . . 9937
61.17.3 fortran code . . . 9940
61.17.4 lisp code . . . 9943
61.18 zsytri . . . 9947
61.18.1 Axiom unit tests . . . 9947
61.18.2 Axiom help page . . . 9948
61.18.3 fortran code . . . 9949
61.18.4 lisp code . . . 9954
61.19 zsytri2 . . . 9964
61.19.1 Axiom unit tests . . . 9964
61.19.2 Axiom help page . . . 9964
61.19.3 fortran code . . . 9966
61.19.4 lisp code . . . 9967
61.20 zsytri2x . . . 9969
61.20.1 Axiom unit tests . . . 9969
61.20.2 Axiom help page . . . 9970
61.20.3 fortran code . . . 9971
61.20.4 lisp code . . . 9980
61.21 zsytri_rook . . . 10000
61.21.1 Axiom unit tests . . . 10000
61.21.2 Axiom help page . . . 10000
61.21.3 fortran code . . . 10002
61.21.4 lisp code . . . 10008
61.22 zsytrs . . . 10020
61.22.1 Axiom unit tests . . . 10020
61.22.2 Axiom help page . . . 10020
61.22.3 fortran code . . . 10022
61.22.4 lisp code . . . 10028
61.23 zsytrs2 . . . 10039
61.23.1 Axiom unit tests . . . 10039
61.23.2 Axiom help page . . . 10039
61.23.3 fortran code . . . 10041
61.23.4 lisp code . . . 10045
61.24 zsytrs_rook . . . 10053
61.24.1 Axiom unit tests . . . 10053
61.24.2 Axiom help page . . . 10054
61.24.3 fortran code . . . 10055
61.24.4 lisp code . . . 10062
61.25 ztgsyl . . . 10074
61.25.1 Axiom unit tests . . . 10074
61.25.2 Axiom help page . . . 10074
61.25.3 fortran code . . . 10078
61.25.4 lisp code . . . 10085

61.26ztrsyl 10101
61.26.1 Axiom unit tests 10101
61.26.2 Axiom help page 10101
61.26.3 fortran code 10103
61.26.4 lisp code 10109

62 LAPACK - Symmetric Matrix, Auxilliary Routines, Double 10121
62.1 dlansy 10121
62.1.1 Axiom unit tests 10121
62.1.2 Axiom help page 10121
62.1.3 fortran code 10123
62.1.4 lisp code 10125
62.2 dlaqsy 10130
62.2.1 Axiom unit tests 10130
62.2.2 Axiom help page 10130
62.2.3 fortran code 10132
62.2.4 lisp code 10134
62.3 dlasy2 10136
62.3.1 Axiom unit tests 10136
62.3.2 Axiom help page 10136
62.3.3 fortran code 10138
62.3.4 lisp code 10144
62.4 dsyswapr 10144
62.4.1 Axiom unit tests 10144
62.4.2 Axiom help page 10145
62.4.3 fortran code 10146
62.4.4 lisp code 10148
62.5 dtgsy2 10148
62.5.1 Axiom unit tests 10148
62.5.2 Axiom help page 10148
62.5.3 fortran code 10152
62.5.4 lisp code 10167

63 LAPACK - Symmetric Matrix, Auxilliary Routines, Real 10205
63.1 slansy 10205
63.1.1 Axiom unit tests 10205
63.1.2 Axiom help page 10205
63.1.3 fortran code 10207
63.1.4 lisp code 10209
63.2 slaqsy 10214
63.2.1 Axiom unit tests 10214
63.2.2 Axiom help page 10214
63.2.3 fortran code 10216
63.2.4 lisp code 10217
63.3 slasy2 10219
63.3.1 Axiom unit tests 10219

63.3.2 Axiom help page . . . 10220
63.3.3 fortran code . . . 10222
63.3.4 lisp code . . . 10228
63.4 ssyswapr . . . 10239
63.4.1 Axiom unit tests . . . 10239
63.4.2 Axiom help page . . . 10239
63.4.3 fortran code . . . 10240
63.4.4 lisp code . . . 10242
63.5 stgsy2 . . . 10242
63.5.1 Axiom unit tests . . . 10242
63.5.2 Axiom help page . . . 10243
63.5.3 fortran code . . . 10246
63.5.4 lisp code . . . 10261

64 LAPACK - Symmetric Matrix, Auxilliary Routines, Complex 10299
64.1 claesy . . . 10299
64.1.1 Axiom unit tests . . . 10299
64.1.2 Axiom help page . . . 10299
64.1.3 fortran code . . . 10301
64.1.4 lisp code . . . 10303
64.2 clansy . . . 10305
64.2.1 Axiom unit tests . . . 10305
64.2.2 Axiom help page . . . 10305
64.2.3 fortran code . . . 10307
64.2.4 lisp code . . . 10309
64.3 claqsy . . . 10314
64.3.1 Axiom unit tests . . . 10314
64.3.2 Axiom help page . . . 10314
64.3.3 fortran code . . . 10316
64.3.4 lisp code . . . 10318
64.4 csymv . . . 10319
64.4.1 Axiom unit tests . . . 10319
64.4.2 Axiom help page . . . 10320
64.4.3 fortran code . . . 10322
64.4.4 lisp code . . . 10325
64.5 csyr . . . 10331
64.5.1 Axiom unit tests . . . 10331
64.5.2 Axiom help page . . . 10331
64.5.3 fortran code . . . 10333
64.5.4 lisp code . . . 10335
64.6 csyswapr . . . 10339
64.6.1 Axiom unit tests . . . 10339
64.6.2 Axiom help page . . . 10339
64.6.3 fortran code . . . 10340
64.6.4 lisp code . . . 10342
64.7 ctgsy2 . . . 10343

64.7.1 Axiom unit tests 10343
64.7.2 Axiom help page 10343
64.7.3 fortran code 10346
64.7.4 lisp code 10351

65 LAPACK - Symmetric Matrix, Auxilliary Routines, Complex16 10359
65.1 zlaesy 10359
65.1.1 Axiom unit tests 10359
65.1.2 Axiom help page 10359
65.1.3 fortran code 10361
65.1.4 lisp code 10363
65.2 zlansy 10365
65.2.1 Axiom unit tests 10365
65.2.2 Axiom help page 10365
65.2.3 fortran code 10367
65.2.4 lisp code 10369
65.3 zlaqsy 10374
65.3.1 Axiom unit tests 10374
65.3.2 Axiom help page 10374
65.3.3 fortran code 10376
65.3.4 lisp code 10378
65.4 zsymv 10379
65.4.1 Axiom unit tests 10379
65.4.2 Axiom help page 10380
65.4.3 fortran code 10382
65.4.4 lisp code 10385
65.5 zsyr 10391
65.5.1 Axiom unit tests 10391
65.5.2 Axiom help page 10391
65.5.3 fortran code 10393
65.5.4 lisp code 10395
65.6 zsyswapr 10399
65.6.1 Axiom unit tests 10399
65.6.2 Axiom help page 10399
65.6.3 fortran code 10400
65.6.4 lisp code 10402
65.7 ztgsy2 10402
65.7.1 Axiom unit tests 10402
65.7.2 Axiom help page 10403
65.7.3 fortran code 10406
65.7.4 lisp code 10410

66 LAPACK - Positive Definite Matrix, Linear Solve, Double 10419
66.1 dposv . . . 10419
66.1.1 Axiom unit tests . . . 10419
66.1.2 Axiom help page . . . 10419
66.1.3 fortran code . . . 10421
66.1.4 lisp code . . . 10422
66.2 dposvx . . . 10424
66.2.1 Axiom unit tests . . . 10424
66.2.2 Axiom help page . . . 10424
66.2.3 fortran code . . . 10429
66.2.4 lisp code . . . 10432
66.3 dposvxx . . . 10438
66.3.1 Axiom unit tests . . . 10438
66.3.2 Axiom help page [**?**] . . . 10438
66.3.3 fortran code . . . 10446
66.3.4 lisp code . . . 10449
66.4 dsposv . . . 10455
66.4.1 Axiom unit tests . . . 10455
66.4.2 Axiom help page . . . 10455
66.4.3 fortran code . . . 10458
66.4.4 lisp code . . . 10463

67 LAPACK - Positive Definite Matrix, Linear Solve, Real 10471
67.1 sposv . . . 10471
67.1.1 Axiom unit tests . . . 10471
67.1.2 Axiom help page . . . 10471
67.1.3 fortran code . . . 10473
67.1.4 lisp code . . . 10474
67.2 sposvx . . . 10476
67.2.1 Axiom unit tests . . . 10476
67.2.2 Axiom help page . . . 10476
67.2.3 fortran code . . . 10481
67.2.4 lisp code . . . 10484
67.3 sposvxx . . . 10490
67.3.1 Axiom unit tests . . . 10490
67.3.2 Axiom help page [**?**] . . . 10490
67.3.3 fortran code . . . 10498
67.3.4 lisp code . . . 10501

68 LAPACK - Positive Definite Matrix, Linear Solve, Complex 10509
68.1 cposv . . . 10509
68.1.1 Axiom unit tests . . . 10509
68.1.2 Axiom help page . . . 10509
68.1.3 fortran code . . . 10511
68.1.4 lisp code . . . 10512
68.2 cposvx . . . 10514

68.2.1 Axiom unit tests . . . 10514
68.2.2 Axiom help page . . . 10514
68.2.3 fortran code . . . 10519
68.2.4 lisp code . . . 10522
68.3 cposvxx . . . 10528
68.3.1 Axiom unit tests . . . 10528
68.3.2 Axiom help page [**?**] . . . 10528
68.3.3 fortran code . . . 10536
68.3.4 lisp code . . . 10539

69 LAPACK - Positive Definite Matrix, Linear Solve, Complex16 10547
69.1 zcposv . . . 10547
69.1.1 Axiom unit tests . . . 10547
69.1.2 Axiom help page . . . 10547
69.1.3 fortran code . . . 10550
69.1.4 lisp code . . . 10555
69.2 zposv . . . 10563
69.2.1 Axiom unit tests . . . 10563
69.2.2 Axiom help page . . . 10563
69.2.3 fortran code . . . 10565
69.2.4 lisp code . . . 10566
69.3 zposvx . . . 10568
69.3.1 Axiom unit tests . . . 10568
69.3.2 Axiom help page . . . 10568
69.3.3 fortran code . . . 10572
69.3.4 lisp code . . . 10576
69.4 zposvxx . . . 10582
69.4.1 Axiom unit tests . . . 10582
69.4.2 Axiom help page [**?**] . . . 10582
69.4.3 fortran code . . . 10589
69.4.4 lisp code . . . 10593

70 LAPACK - Positive Definite Matrix, Comp. Routines, Double 10599
70.1 dla_porcond . . . 10599
70.1.1 Axiom unit tests . . . 10599
70.1.2 Axiom help page . . . 10599
70.1.3 fortran code . . . 10601
70.1.4 lisp code . . . 10605
70.2 dla_porfsx_extended . . . 10611
70.2.1 Axiom unit tests . . . 10611
70.2.2 Axiom help page [**?**] . . . 10612
70.2.3 fortran code . . . 10617
70.2.4 lisp code . . . 10623
70.3 dla_porpvgrw . . . 10630
70.3.1 Axiom unit tests . . . 10630
70.3.2 Axiom help page . . . 10630

70.3.3 fortran code . . . 10632
70.3.4 lisp code . . . 10634
70.4 dpocon . . . 10637
70.4.1 Axiom unit tests . . . 10637
70.4.2 Axiom help page . . . 10637
70.4.3 fortran code . . . 10639
70.4.4 lisp code . . . 10641
70.5 dpoequ . . . 10645
70.5.1 Axiom unit tests . . . 10645
70.5.2 Axiom help page . . . 10645
70.5.3 fortran code . . . 10647
70.5.4 lisp code . . . 10648
70.6 dpoequb . . . 10650
70.6.1 Axiom unit tests . . . 10650
70.6.2 Axiom help page . . . 10650
70.6.3 fortran code . . . 10652
70.6.4 lisp code . . . 10654
70.7 dporfs . . . 10656
70.7.1 Axiom unit tests . . . 10656
70.7.2 Axiom help page . . . 10656
70.7.3 fortran code . . . 10658
70.7.4 lisp code . . . 10663
70.8 dporfsx . . . 10671
70.8.1 Axiom unit tests . . . 10671
70.8.2 Axiom help page citeDemm05 . . . 10671
70.8.3 fortran code . . . 10677
70.8.4 lisp code . . . 10683
70.9 dpotf2 . . . 10683
70.9.1 Axiom unit tests . . . 10683
70.9.2 Axiom help page . . . 10683
70.9.3 fortran code . . . 10685
70.9.4 lisp code . . . 10687
70.10dpotrf . . . 10691
70.10.1 Axiom unit tests . . . 10691
70.10.2 Axiom help page . . . 10691
70.10.3 fortran code . . . 10692
70.10.4 lisp code . . . 10695
70.11dpotrf2 . . . 10700
70.11.1 Axiom unit tests . . . 10700
70.11.2 Axiom help page . . . 10700
70.11.3 fortran code . . . 10702
70.11.4 lisp code . . . 10704
70.12dpotri . . . 10708
70.12.1 Axiom unit tests . . . 10708
70.12.2 Axiom help page . . . 10708
70.12.3 fortran code . . . 10709

70.12.4 lisp code . . . 10710
70.13 dpotrs . . . 10712
70.13.1 Axiom unit tests . . . 10712
70.13.2 Axiom help page . . . 10712
70.13.3 fortran code . . . 10714
70.13.4 lisp code . . . 10715

71 LAPACK - Positive Definite Matrix, Comp. Routines, Real 10719
71.1 sla_porcond . . . 10719
71.1.1 Axiom unit tests . . . 10719
71.1.2 Axiom help page . . . 10719
71.1.3 fortran code . . . 10721
71.1.4 lisp code . . . 10725
71.2 sla_porfsx_extended . . . 10731
71.2.1 Axiom unit tests . . . 10731
71.2.2 Axiom help page [**?**] . . . 10732
71.2.3 fortran code . . . 10737
71.2.4 lisp code . . . 10743
71.3 sla_porpvgrw . . . 10750
71.3.1 Axiom unit tests . . . 10750
71.3.2 Axiom help page . . . 10750
71.3.3 fortran code . . . 10752
71.3.4 lisp code . . . 10754
71.4 spocon . . . 10757
71.4.1 Axiom unit tests . . . 10757
71.4.2 Axiom help page . . . 10757
71.4.3 fortran code . . . 10758
71.4.4 lisp code . . . 10761
71.5 spoequ . . . 10765
71.5.1 Axiom unit tests . . . 10765
71.5.2 Axiom help page . . . 10765
71.5.3 fortran code . . . 10766
71.5.4 lisp code . . . 10768
71.6 spoequb . . . 10770
71.6.1 Axiom unit tests . . . 10770
71.6.2 Axiom help page . . . 10770
71.6.3 fortran code . . . 10772
71.6.4 lisp code . . . 10774
71.7 sporfs . . . 10775
71.7.1 Axiom unit tests . . . 10775
71.7.2 Axiom help page . . . 10776
71.7.3 fortran code . . . 10778
71.7.4 lisp code . . . 10783
71.8 sporfsx . . . 10791
71.8.1 Axiom unit tests . . . 10791
71.8.2 Axiom help page [**?**] . . . 10791

71.8.3 fortran code . . . 10797
71.8.4 lisp code . . . 10803
71.9 spotf2 . . . 10803
71.9.1 Axiom unit tests . . . 10803
71.9.2 Axiom help page . . . 10803
71.9.3 fortran code . . . 10805
71.9.4 lisp code . . . 10807
71.10 spotrf . . . 10810
71.10.1 Axiom unit tests . . . 10810
71.10.2 Axiom help page . . . 10811
71.10.3 fortran code . . . 10812
71.10.4 lisp code . . . 10815
71.11 spotrf2 . . . 10820
71.11.1 Axiom unit tests . . . 10820
71.11.2 Axiom help page . . . 10820
71.11.3 fortran code . . . 10821
71.11.4 lisp code . . . 10824
71.12 spotri . . . 10827
71.12.1 Axiom unit tests . . . 10827
71.12.2 Axiom help page . . . 10828
71.12.3 fortran code . . . 10829
71.12.4 lisp code . . . 10830
71.13 spotrs . . . 10832
71.13.1 Axiom unit tests . . . 10832
71.13.2 Axiom help page . . . 10832
71.13.3 fortran code . . . 10833
71.13.4 lisp code . . . 10835

72 LAPACK - Positive Definite Matrix, Comp. Routines, Complex 10839
72.1 cla_porcond_c . . . 10839
72.1.1 Axiom unit tests . . . 10839
72.1.2 Axiom help page . . . 10839
72.1.3 fortran code . . . 10841
72.1.4 lisp code . . . 10845
72.2 cla_porcond_x . . . 10850
72.2.1 Axiom unit tests . . . 10850
72.2.2 Axiom help page . . . 10851
72.2.3 fortran code . . . 10852
72.2.4 lisp code . . . 10855
72.3 cla_porfsx_extended . . . 10860
72.3.1 Axiom unit tests . . . 10860
72.3.2 Axiom help page [**?**] . . . 10861
72.3.3 fortran code . . . 10866
72.3.4 lisp code . . . 10872
72.4 cla_porpvgrw . . . 10879
72.4.1 Axiom unit tests . . . 10879

72.4.2 Axiom help page . . . 10880
72.4.3 fortran code . . . 10881
72.4.4 lisp code . . . 10883
72.5 cpocon . . . 10886
72.5.1 Axiom unit tests . . . 10886
72.5.2 Axiom help page . . . 10887
72.5.3 fortran code . . . 10888
72.5.4 lisp code . . . 10891
72.6 cpoequ . . . 10894
72.6.1 Axiom unit tests . . . 10894
72.6.2 Axiom help page . . . 10895
72.6.3 fortran code . . . 10896
72.6.4 lisp code . . . 10898
72.7 cpoequb . . . 10900
72.7.1 Axiom unit tests . . . 10900
72.7.2 Axiom help page . . . 10900
72.7.3 fortran code . . . 10901
72.7.4 lisp code . . . 10903
72.8 cporfs . . . 10905
72.8.1 Axiom unit tests . . . 10905
72.8.2 Axiom help page . . . 10906
72.8.3 fortran code . . . 10908
72.8.4 lisp code . . . 10913
72.9 cporfsx . . . 10921
72.9.1 Axiom unit tests . . . 10921
72.9.2 Axiom help page [**?**] . . . 10921
72.9.3 fortran code . . . 10927
72.9.4 lisp code . . . 10933
72.10 cpotf2 . . . 10933
72.10.1 Axiom unit tests . . . 10933
72.10.2 Axiom help page . . . 10933
72.10.3 fortran code . . . 10935
72.10.4 lisp code . . . 10937
72.11 cpotrf . . . 10941
72.11.1 Axiom unit tests . . . 10941
72.11.2 Axiom help page . . . 10942
72.11.3 fortran code . . . 10943
72.11.4 lisp code . . . 10946
72.12 cpotrf2 . . . 10951
72.12.1 Axiom unit tests . . . 10951
72.12.2 Axiom help page . . . 10951
72.12.3 fortran code . . . 10952
72.12.4 lisp code . . . 10955
72.13 cpotri . . . 10959
72.13.1 Axiom unit tests . . . 10959
72.13.2 Axiom help page . . . 10959

72.13.3 fortran code . . . 10960
72.13.4 lisp code . . . 10961
72.14 cpotrs . . . 10963
72.14.1 Axiom unit tests . . . 10963
72.14.2 Axiom help page . . . 10963
72.14.3 fortran code . . . 10965
72.14.4 lisp code . . . 10967

73 LAPACK - Positive Definite Matrix, Comp. Routines, Complex16 10971
73.1 zla_porcond_c . . . 10971
73.1.1 Axiom unit tests . . . 10971
73.1.2 Axiom help page . . . 10971
73.1.3 fortran code . . . 10973
73.1.4 lisp code . . . 10977
73.2 zla_porcond_x . . . 10982
73.2.1 Axiom unit tests . . . 10982
73.2.2 Axiom help page . . . 10983
73.2.3 fortran code . . . 10984
73.2.4 lisp code . . . 10988
73.3 zla_porfsx_extended . . . 10993
73.3.1 Axiom unit tests . . . 10993
73.3.2 Axiom help page [**?**] . . . 10993
73.3.3 fortran code . . . 10998
73.3.4 lisp code . . . 11004
73.4 zla_porpvgrw . . . 11012
73.4.1 Axiom unit tests . . . 11012
73.4.2 Axiom help page . . . 11012
73.4.3 fortran code . . . 11013
73.4.4 lisp code . . . 11016
73.5 zpocon . . . 11019
73.5.1 Axiom unit tests . . . 11019
73.5.2 Axiom help page . . . 11019
73.5.3 fortran code . . . 11021
73.5.4 lisp code . . . 11023
73.6 zpoequ . . . 11027
73.6.1 Axiom unit tests . . . 11027
73.6.2 Axiom help page . . . 11027
73.6.3 fortran code . . . 11029
73.6.4 lisp code . . . 11030
73.7 zpoequb . . . 11032
73.7.1 Axiom unit tests . . . 11032
73.7.2 Axiom help page . . . 11033
73.7.3 fortran code . . . 11034
73.7.4 lisp code . . . 11036
73.8 zporfs . . . 11038
73.8.1 Axiom unit tests . . . 11038

73.8.2 Axiom help page . . . 11038
73.8.3 fortran code . . . 11041
73.8.4 lisp code . . . 11045
73.9 zporfsx . . . 11053
73.9.1 Axiom unit tests . . . 11053
73.9.2 Axiom help page [**?**] . . . 11054
73.9.3 fortran code . . . 11060
73.9.4 lisp code . . . 11065
73.10 zpotf2 . . . 11066
73.10.1 Axiom unit tests . . . 11066
73.10.2 Axiom help page . . . 11066
73.10.3 fortran code . . . 11067
73.10.4 lisp code . . . 11070
73.11 zpotrf . . . 11074
73.11.1 Axiom unit tests . . . 11074
73.11.2 Axiom help page . . . 11074
73.11.3 fortran code . . . 11076
73.11.4 lisp code . . . 11079
73.12 zpotrf2 . . . 11083
73.12.1 Axiom unit tests . . . 11083
73.12.2 Axiom help page . . . 11084
73.12.3 fortran code . . . 11085
73.12.4 lisp code . . . 11088
73.13 zpotri . . . 11091
73.13.1 Axiom unit tests . . . 11091
73.13.2 Axiom help page . . . 11092
73.13.3 fortran code . . . 11093
73.13.4 lisp code . . . 11094
73.14 zpotrs . . . 11096
73.14.1 Axiom unit tests . . . 11096
73.14.2 Axiom help page . . . 11096
73.14.3 fortran code . . . 11097
73.14.4 lisp code . . . 11099

74 LAPACK - General Tridiagonal Matrix, Linear Solve, Double 11103
74.1 dgtsv . . . 11103
74.1.1 Axiom unit tests . . . 11103
74.1.2 Axiom help page . . . 11103
74.1.3 fortran code . . . 11105
74.1.4 lisp code . . . 11109
74.2 dgtsvx . . . 11117
74.2.1 Axiom unit tests . . . 11117
74.2.2 Axiom help page . . . 11117
74.2.3 fortran code . . . 11121
74.2.4 lisp code . . . 11123

75 LAPACK - General Tridiagonal Matrix, Linear Solve, Real 11129
75.1 sgtsv . . . 11129
75.1.1 Axiom unit tests . . . 11129
75.1.2 Axiom help page . . . 11129
75.1.3 fortran code . . . 11131
75.1.4 lisp code . . . 11135
75.2 sgtsvx . . . 11143
75.2.1 Axiom unit tests . . . 11143
75.2.2 Axiom help page . . . 11143
75.2.3 fortran code . . . 11147
75.2.4 lisp code . . . 11149

76 LAPACK - General Tridiagonal Matrix, Linear Solve, Complex 11155
76.1 cgtsv . . . 11155
76.1.1 Axiom unit tests . . . 11155
76.1.2 Axiom help page . . . 11155
76.1.3 fortran code . . . 11157
76.1.4 lisp code . . . 11159
76.2 cgtsvx . . . 11163
76.2.1 Axiom unit tests . . . 11163
76.2.2 Axiom help page . . . 11163
76.2.3 fortran code . . . 11167
76.2.4 lisp code . . . 11170

77 LAPACK - General Tridiagonal Matrix, Linear Solve, Complex16 11175
77.1 zgtsv . . . 11175
77.1.1 Axiom unit tests . . . 11175
77.1.2 Axiom help page . . . 11175
77.1.3 fortran code . . . 11177
77.1.4 lisp code . . . 11179
77.2 zgtsvx . . . 11183
77.2.1 Axiom unit tests . . . 11183
77.2.2 Axiom help page . . . 11183
77.2.3 fortran code . . . 11187
77.2.4 lisp code . . . 11190

78 LAPACK - General Tridiagonal Matrix, Comp. Routines, Double 11195
78.1 dgtcon . . . 11195
78.1.1 Axiom unit tests . . . 11195
78.1.2 Axiom help page . . . 11195
78.1.3 fortran code . . . 11197
78.1.4 lisp code . . . 11199
78.2 dgtrfs . . . 11202
78.2.1 Axiom unit tests . . . 11202
78.2.2 Axiom help page . . . 11202
78.2.3 fortran code . . . 11205

78.2.4 lisp code 11210
78.3 dgttrf 11219
78.3.1 Axiom unit tests 11219
78.3.2 Axiom help page 11219
78.3.3 fortran code 11221
78.3.4 lisp code 11223
78.4 dgttrs 11226
78.4.1 Axiom unit tests 11226
78.4.2 Axiom help page 11227
78.4.3 fortran code 11228
78.4.4 lisp code 11230
78.5 dgtts2 11232
78.5.1 Axiom unit tests 11232
78.5.2 Axiom help page 11233
78.5.3 fortran code 11234
78.5.4 lisp code 11237

79 LAPACK - General Tridiagonal Matrix, Comp. Routines, Real 11245
79.1 sgtcon 11245
79.1.1 Axiom unit tests 11245
79.1.2 Axiom help page 11245
79.1.3 fortran code 11247
79.1.4 lisp code 11249
79.2 sgtrfs 11252
79.2.1 Axiom unit tests 11252
79.2.2 Axiom help page 11252
79.2.3 fortran code 11255
79.2.4 lisp code 11260
79.3 sgttrf 11269
79.3.1 Axiom unit tests 11269
79.3.2 Axiom help page 11269
79.3.3 fortran code 11271
79.3.4 lisp code 11273
79.4 sgttrs 11276
79.4.1 Axiom unit tests 11276
79.4.2 Axiom help page 11276
79.4.3 fortran code 11278
79.4.4 lisp code 11280
79.5 sgtts2 11282
79.5.1 Axiom unit tests 11282
79.5.2 Axiom help page 11282
79.5.3 fortran code 11284
79.5.4 lisp code 11287

80 LAPACK - General Tridiagonal Matrix, Comp. Routines, Complex 11295
80.1 cgtcon . . . 11295
80.1.1 Axiom unit tests . . . 11295
80.1.2 Axiom help page . . . 11295
80.1.3 fortran code . . . 11297
80.1.4 lisp code . . . 11299
80.2 cgtrfs . . . 11302
80.2.1 Axiom unit tests . . . 11302
80.2.2 Axiom help page . . . 11302
80.2.3 fortran code . . . 11305
80.2.4 lisp code . . . 11310
80.3 cgttrf . . . 11320
80.3.1 Axiom unit tests . . . 11320
80.3.2 Axiom help page . . . 11320
80.3.3 fortran code . . . 11322
80.3.4 lisp code . . . 11324
80.4 cgttrs . . . 11327
80.4.1 Axiom unit tests . . . 11327
80.4.2 Axiom help page . . . 11328
80.4.3 fortran code . . . 11329
80.4.4 lisp code . . . 11331
80.5 cgtts2 . . . 11333
80.5.1 Axiom unit tests . . . 11333
80.5.2 Axiom help page . . . 11334
80.5.3 fortran code . . . 11335
80.5.4 lisp code . . . 11340

81 LAPACK - General Tridiagonal Matrix, Comp. Routines, Complex16 11351
81.1 zgtcon . . . 11351
81.1.1 Axiom unit tests . . . 11351
81.1.2 Axiom help page . . . 11351
81.1.3 fortran code . . . 11353
81.1.4 lisp code . . . 11355
81.2 zgtrfs . . . 11358
81.2.1 Axiom unit tests . . . 11358
81.2.2 Axiom help page . . . 11358
81.2.3 fortran code . . . 11361
81.2.4 lisp code . . . 11366
81.3 zgttrf . . . 11376
81.3.1 Axiom unit tests . . . 11376
81.3.2 Axiom help page . . . 11376
81.3.3 fortran code . . . 11378
81.3.4 lisp code . . . 11380
81.4 zgttrs . . . 11383
81.4.1 Axiom unit tests . . . 11383
81.4.2 Axiom help page . . . 11384

81.4.3 fortran code . . . 11385
81.4.4 lisp code . . . 11387
81.5 zgtts2 . . . 11390
81.5.1 Axiom unit tests . . . 11390
81.5.2 Axiom help page . . . 11390
81.5.3 fortran code . . . 11392
81.5.4 lisp code . . . 11396

82 LAPACK - Positive Definite Tridiagonal Matrix, Linear Solve, Double 11407
82.1 dptsv . . . 11407
82.1.1 Axiom unit tests . . . 11407
82.1.2 Axiom help page . . . 11407
82.1.3 fortran code . . . 11409
82.1.4 lisp code . . . 11410
82.2 dptsvx . . . 11411
82.2.1 Axiom unit tests . . . 11411
82.2.2 Axiom help page . . . 11411
82.2.3 fortran code . . . 11415
82.2.4 lisp code . . . 11417

83 LAPACK - Positive Definite Tridiagonal Matrix, Linear Solve, Real 11421
83.1 sptsv . . . 11421
83.1.1 Axiom unit tests . . . 11421
83.1.2 Axiom help page . . . 11421
83.1.3 fortran code . . . 11423
83.1.4 lisp code . . . 11424
83.2 sptsvx . . . 11425
83.2.1 Axiom unit tests . . . 11425
83.2.2 Axiom help page . . . 11425
83.2.3 fortran code . . . 11429
83.2.4 lisp code . . . 11431

84 LAPACK - Positive Definite Tridiagonal Matrix, Linear Solve, Complex 11435
84.1 cptsv . . . 11435
84.1.1 Axiom unit tests . . . 11435
84.1.2 Axiom help page . . . 11435
84.1.3 fortran code . . . 11437
84.1.4 lisp code . . . 11438
84.2 cptsvx . . . 11439
84.2.1 Axiom unit tests . . . 11439
84.2.2 Axiom help page . . . 11440
84.2.3 fortran code . . . 11443
84.2.4 lisp code . . . 11445

85 LAPACK - Positive Definite Tridiagonal Matrix, Linear Solve, Complex16 11449
85.1 zptsv . . . 11449
85.1.1 Axiom unit tests . . . 11449
85.1.2 Axiom help page . . . 11449
85.1.3 fortran code . . . 11451
85.1.4 lisp code . . . 11452
85.2 zptsvx . . . 11453
85.2.1 Axiom unit tests . . . 11453
85.2.2 Axiom help page . . . 11454
85.2.3 fortran code . . . 11457
85.2.4 lisp code . . . 11459

86 LAPACK - Positive Definite Tridiagonal Matrix, Comp. Routines, Double 11463
86.1 dptcon . . . 11463
86.1.1 Axiom unit tests . . . 11463
86.1.2 Axiom help page . . . 11463
86.1.3 fortran code . . . 11465
86.1.4 lisp code . . . 11467
86.2 dpteqr . . . 11469
86.2.1 Axiom unit tests . . . 11469
86.2.2 Axiom help page . . . 11469
86.2.3 fortran code . . . 11471
86.2.4 lisp code . . . 11473
86.3 dptrfs . . . 11476
86.3.1 Axiom unit tests . . . 11476
86.3.2 Axiom help page . . . 11476
86.3.3 fortran code . . . 11478
86.3.4 lisp code . . . 11483
86.4 dpttrf . . . 11489
86.4.1 Axiom unit tests . . . 11489
86.4.2 Axiom help page . . . 11489
86.4.3 fortran code . . . 11490
86.4.4 lisp code . . . 11492
86.5 dpttrs . . . 11495
86.5.1 Axiom unit tests . . . 11495
86.5.2 Axiom help page . . . 11495
86.5.3 fortran code . . . 11497
86.5.4 lisp code . . . 11498
86.6 dptts2 . . . 11500
86.6.1 Axiom unit tests . . . 11500
86.6.2 Axiom help page . . . 11500
86.6.3 fortran code . . . 11502
86.6.4 lisp code . . . 11503

87 LAPACK - Positive Definite Tridiagonal Matrix, Comp. Routines, Real 11505
87.1 sptcon . . . 11505
87.1.1 Axiom unit tests . . . 11505
87.1.2 Axiom help page . . . 11505
87.1.3 fortran code . . . 11507
87.1.4 lisp code . . . 11509
87.2 spteqr . . . 11511
87.2.1 Axiom unit tests . . . 11511
87.2.2 Axiom help page . . . 11511
87.2.3 fortran code . . . 11513
87.2.4 lisp code . . . 11515
87.3 sptrfs . . . 11518
87.3.1 Axiom unit tests . . . 11518
87.3.2 Axiom help page . . . 11518
87.3.3 fortran code . . . 11520
87.3.4 lisp code . . . 11525
87.4 spttrf . . . 11531
87.4.1 Axiom unit tests . . . 11531
87.4.2 Axiom help page . . . 11531
87.4.3 fortran code . . . 11532
87.4.4 lisp code . . . 11534
87.5 spttrs . . . 11537
87.5.1 Axiom unit tests . . . 11537
87.5.2 Axiom help page . . . 11537
87.5.3 fortran code . . . 11539
87.5.4 lisp code . . . 11540
87.6 sptts2 . . . 11542
87.6.1 Axiom unit tests . . . 11542
87.6.2 Axiom help page . . . 11542
87.6.3 fortran code . . . 11544
87.6.4 lisp code . . . 11545

88 LAPACK - Positive Definite Tridiagonal Matrix, Comp. Routines, Complex 11547
88.1 cptcon . . . 11547
88.1.1 Axiom unit tests . . . 11547
88.1.2 Axiom help page . . . 11547
88.1.3 fortran code . . . 11549
88.1.4 lisp code . . . 11551
88.2 cpteqr . . . 11553
88.2.1 Axiom unit tests . . . 11553
88.2.2 Axiom help page . . . 11553
88.2.3 fortran code . . . 11555
88.2.4 lisp code . . . 11557
88.3 cptrfs . . . 11560
88.3.1 Axiom unit tests . . . 11560

88.3.2 Axiom help page . . . 11560
88.3.3 fortran code . . . 11562
88.3.4 lisp code . . . 11568
88.4 cpttrf . . . 11578
88.4.1 Axiom unit tests . . . 11578
88.4.2 Axiom help page . . . 11578
88.4.3 fortran code . . . 11579
88.4.4 lisp code . . . 11582
88.5 cpttrs . . . 11585
88.5.1 Axiom unit tests . . . 11585
88.5.2 Axiom help page . . . 11585
88.5.3 fortran code . . . 11587
88.5.4 lisp code . . . 11589
88.6 cptts2 . . . 11591
88.6.1 Axiom unit tests . . . 11591
88.6.2 Axiom help page . . . 11591
88.6.3 fortran code . . . 11593
88.6.4 lisp code . . . 11595

89 LAPACK - Positive Definite Tridiagonal Matrix, Comp. Routines, Complex16 11601
89.1 zptcon . . . 11601
89.1.1 Axiom unit tests . . . 11601
89.1.2 Axiom help page . . . 11601
89.1.3 fortran code . . . 11603
89.1.4 lisp code . . . 11605
89.2 zpteqr . . . 11607
89.2.1 Axiom unit tests . . . 11607
89.2.2 Axiom help page . . . 11607
89.2.3 fortran code . . . 11609
89.2.4 lisp code . . . 11611
89.3 zptrfs . . . 11614
89.3.1 Axiom unit tests . . . 11614
89.3.2 Axiom help page . . . 11614
89.3.3 fortran code . . . 11616
89.3.4 lisp code . . . 11622
89.4 zpttrf . . . 11632
89.4.1 Axiom unit tests . . . 11632
89.4.2 Axiom help page . . . 11632
89.4.3 fortran code . . . 11633
89.4.4 lisp code . . . 11636
89.5 zpttrs . . . 11639
89.5.1 Axiom unit tests . . . 11639
89.5.2 Axiom help page . . . 11639
89.5.3 fortran code . . . 11641
89.5.4 lisp code . . . 11643

89.6 zptts2 11645
89.6.1 Axiom unit tests 11645
89.6.2 Axiom help page 11645
89.6.3 fortran code 11647
89.6.4 lisp code 11649

90 LAPACK - Other Auxilliary Routines 11655
90.1 disnan 11655
90.1.1 Axiom unit tests 11655
90.1.2 Axiom help page 11655
90.1.3 fortran code 11656
90.1.4 lisp code 11657
90.2 dlabad 11657
90.2.1 Axiom unit tests 11657
90.2.2 Axiom help page 11657
90.2.3 fortran code 11658
90.2.4 lisp code 11659
90.3 dlacpy 11659
90.3.1 Axiom unit tests 11659
90.3.2 Axiom help page 11659
90.3.3 fortran code 11660
90.3.4 lisp code 11662
90.4 dladiv 11662
90.4.1 Axiom unit tests 11662
90.4.2 Axiom help page 11662
90.4.3 fortran code 11663
90.4.4 lisp code 11667
90.5 dlae2 11667
90.5.1 Axiom unit tests 11667
90.5.2 Axiom help page 11667
90.5.3 fortran code 11668
90.5.4 lisp code 11670
90.6 dlaebz 11671
90.6.1 Axiom unit tests 11671
90.6.2 Axiom help page 11672
90.6.3 fortran code 11676
90.6.4 lisp code 11683
90.7 dlaev2 11692
90.7.1 Axiom unit tests 11692
90.7.2 Axiom help page 11692
90.7.3 fortran code 11694
90.7.4 lisp code 11696
90.8 dlagts 11698
90.8.1 Axiom unit tests 11698
90.8.2 Axiom help page 11698
90.8.3 fortran code 11700

90.8.4 lisp code 11704
90.9 dlaisnan 11711
90.9.1 Axiom unit tests 11711
90.9.2 Axiom help page 11711
90.9.3 fortran code 11712
90.9.4 lisp code 11712
90.10dlamc1 11713
90.10.1 Axiom unit tests 11713
90.10.2 Axiom help page 11713
90.10.3 fortran code 11714
90.10.4 lisp code 11714
90.11dlamc2 11714
90.11.1 Axiom unit tests 11714
90.11.2 Axiom help page 11714
90.11.3 fortran code 11715
90.11.4 lisp code 11715
90.12dlamc3 11716
90.12.1 Axiom unit tests 11716
90.12.2 Axiom help page 11716
90.12.3 fortran code 11716
90.12.4 lisp code 11717
90.13dlamch 11717
90.13.1 Axiom unit tests 11717
90.13.2 Axiom help page 11717
90.13.3 fortran code 11718
90.13.4 lisp code 11718
90.14dlaneg 11719
90.14.1 Axiom unit tests 11719
90.14.2 Axiom help page 11719
90.14.3 fortran code 11720
90.14.4 lisp code 11723
90.15dlanst 11726
90.15.1 Axiom unit tests 11726
90.15.2 Axiom help page 11726
90.15.3 fortran code 11728
90.15.4 lisp code 11730
90.16dlapy2 11730
90.16.1 Axiom unit tests 11730
90.16.2 Axiom help page 11730
90.16.3 fortran code 11731
90.16.4 lisp code 11732
90.17dlapy3 11732
90.17.1 Axiom unit tests 11732
90.17.2 Axiom help page 11732
90.17.3 fortran code 11733
90.17.4 lisp code 11734

90.18dlarnv 11734
90.18.1 Axiom unit tests 11734
90.18.2 Axiom help page 11735
90.18.3 fortran code 11736
90.18.4 lisp code 11737
90.19dlarra 11739
90.19.1 Axiom unit tests 11739
90.19.2 Axiom help page 11740
90.19.3 fortran code 11741
90.19.4 lisp code 11743
90.20dlarrb 11744
90.20.1 Axiom unit tests 11744
90.20.2 Axiom help page 11745
90.20.3 fortran code 11747
90.20.4 lisp code 11751
90.21dlarrc 11755
90.21.1 Axiom unit tests 11755
90.21.2 Axiom help page 11756
90.21.3 fortran code 11757
90.21.4 lisp code 11759
90.22dlarrd 11762
90.22.1 Axiom unit tests 11762
90.22.2 Axiom help page 11762
90.22.3 fortran code 11766
90.22.4 lisp code 11776
90.23dlarre 11790
90.23.1 Axiom unit tests 11790
90.23.2 Axiom help page 11790
90.23.3 fortran code 11794
90.23.4 lisp code 11805
90.24dlarrf 11821
90.24.1 Axiom unit tests 11821
90.24.2 Axiom help page 11822
90.24.3 fortran code 11824
90.24.4 lisp code 11830
90.25dlarrj 11837
90.25.1 Axiom unit tests 11837
90.25.2 Axiom help page 11837
90.25.3 fortran code 11839
90.25.4 lisp code 11843
90.26dlarrk 11848
90.26.1 Axiom unit tests 11848
90.26.2 Axiom help page 11849
90.26.3 fortran code 11851
90.26.4 lisp code 11853
90.27dlarrr 11855

90.27.1 Axiom unit tests . . . 11855
90.27.2 Axiom help page . . . 11855
90.27.3 fortran code . . . 11856
90.27.4 lisp code . . . 11858
90.28 dlartg . . . 11860
90.28.1 Axiom unit tests . . . 11860
90.28.2 Axiom help page . . . 11860
90.28.3 fortran code . . . 11861
90.28.4 lisp code . . . 11864
90.29 dlartgp . . . 11864
90.29.1 Axiom unit tests . . . 11864
90.29.2 Axiom help page . . . 11864
90.29.3 fortran code . . . 11865
90.29.4 lisp code . . . 11867
90.30 dlaruv . . . 11869
90.30.1 Axiom unit tests . . . 11869
90.30.2 Axiom help page . . . 11870
90.30.3 fortran code . . . 11871
90.30.4 lisp code . . . 11877
90.31 dlas2 . . . 11885
90.31.1 Axiom unit tests . . . 11885
90.31.2 Axiom help page . . . 11885
90.31.3 fortran code . . . 11887
90.31.4 lisp code . . . 11888
90.32 dlascl . . . 11889
90.32.1 Axiom unit tests . . . 11889
90.32.2 Axiom help page . . . 11889
90.32.3 fortran code . . . 11891
90.32.4 lisp code . . . 11895
90.33 dlasd0 . . . 11896
90.33.1 Axiom unit tests . . . 11896
90.33.2 Axiom help page . . . 11896
90.33.3 fortran code . . . 11898
90.33.4 lisp code . . . 11901
90.34 dlasd1 . . . 11902
90.34.1 Axiom unit tests . . . 11902
90.34.2 Axiom help page . . . 11902
90.34.3 fortran code . . . 11905
90.34.4 lisp code . . . 11907
90.35 dlasd2 . . . 11907
90.35.1 Axiom unit tests . . . 11907
90.35.2 Axiom help page . . . 11908
90.35.3 fortran code . . . 11911
90.35.4 lisp code . . . 11918
90.36 dlasd3 . . . 11918
90.36.1 Axiom unit tests . . . 11918

90.36.2 Axiom help page . . . 11919
90.36.3 fortran code . . . 11922
90.36.4 lisp code . . . 11926
90.37 dlasd4 . . . 11927
90.37.1 Axiom unit tests . . . 11927
90.37.2 Axiom help page . . . 11927
90.37.3 fortran code . . . 11929
90.37.4 lisp code . . . 11946
90.38 dlasd5 . . . 11946
90.38.1 Axiom unit tests . . . 11946
90.38.2 Axiom help page . . . 11946
90.38.3 fortran code . . . 11948
90.38.4 lisp code . . . 11950
90.39 dlasd6 . . . 11950
90.39.1 Axiom unit tests . . . 11950
90.39.2 Axiom help page . . . 11951
90.39.3 fortran code . . . 11955
90.39.4 lisp code . . . 11958
90.40 dlasd7 . . . 11958
90.40.1 Axiom unit tests . . . 11958
90.40.2 Axiom help page . . . 11958
90.40.3 fortran code . . . 11962
90.40.4 lisp code . . . 11968
90.41 dlasd8 . . . 11968
90.41.1 Axiom unit tests . . . 11968
90.41.2 Axiom help page . . . 11968
90.41.3 fortran code . . . 11970
90.41.4 lisp code . . . 11974
90.42 dlasda . . . 11974
90.42.1 Axiom unit tests . . . 11974
90.42.2 Axiom help page . . . 11974
90.42.3 fortran code . . . 11978
90.42.4 lisp code . . . 11983
90.43 dlasdq . . . 11983
90.43.1 Axiom unit tests . . . 11983
90.43.2 Axiom help page . . . 11983
90.43.3 fortran code . . . 11986
90.43.4 lisp code . . . 11990
90.44 dlasdt . . . 11990
90.44.1 Axiom unit tests . . . 11990
90.44.2 Axiom help page . . . 11990
90.44.3 fortran code . . . 11991
90.44.4 lisp code . . . 11993
90.45 dlaset . . . 11993
90.45.1 Axiom unit tests . . . 11993
90.45.2 Axiom help page . . . 11993

90.45.3 fortran code . . . 11995
90.45.4 lisp code . . . 11996
90.46 dlasr . . . 11997
90.46.1 Axiom unit tests . . . 11997
90.46.2 Axiom help page . . . 11997
90.46.3 fortran code . . . 12000
90.46.4 lisp code . . . 12004
90.47 dlassq . . . 12005
90.47.1 Axiom unit tests . . . 12005
90.47.2 Axiom help page . . . 12005
90.47.3 fortran code . . . 12006
90.47.4 lisp code . . . 12007
90.48 dlasv2 . . . 12008
90.48.1 Axiom unit tests . . . 12008
90.48.2 Axiom help page . . . 12008
90.48.3 fortran code . . . 12010
90.48.4 lisp code . . . 12013
90.49 dsecnd . . . 12014
90.49.1 Axiom unit tests . . . 12014
90.49.2 Axiom help page . . . 12014
90.49.3 fortran code . . . 12014
90.49.4 lisp code . . . 12014
90.50 ieeeck . . . 12015
90.50.1 Axiom unit tests . . . 12015
90.50.2 Axiom help page . . . 12015
90.50.3 fortran code . . . 12016
90.50.4 lisp code . . . 12018
90.51 iladlc . . . 12019
90.51.1 Axiom unit tests . . . 12019
90.51.2 Axiom help page . . . 12019
90.51.3 fortran code . . . 12020
90.51.4 lisp code . . . 12021
90.52 iladlr . . . 12022
90.52.1 Axiom unit tests . . . 12022
90.52.2 Axiom help page . . . 12022
90.52.3 fortran code . . . 12023
90.52.4 lisp code . . . 12024
90.53 ilaenv . . . 12025
90.53.1 Axiom unit tests . . . 12025
90.53.2 Axiom help page . . . 12025
90.53.3 fortran code . . . 12027
90.53.4 lisp code . . . 12036
90.54 ilaver . . . 12037
90.54.1 Axiom unit tests . . . 12037
90.54.2 Axiom help page . . . 12037
90.54.3 fortran code . . . 12038

90.54.4 lisp code 12038
90.55 iparmq 12039
90.55.1 Axiom unit tests 12039
90.55.2 Axiom help page 12039
90.55.3 fortran code 12042
90.55.4 lisp code 12046
90.56 lsame 12049
90.56.1 Axiom unit tests 12049
90.56.2 Axiom help page 12049
90.56.3 fortran code 12050
90.56.4 lisp code 12051
90.57 lsamen 12052
90.57.1 Axiom unit tests 12052
90.57.2 Axiom help page 12052
90.57.3 fortran code 12053
90.57.4 lisp code 12054
90.58 second 12055
90.58.1 Axiom unit tests 12055
90.58.2 Axiom help page 12055
90.58.3 fortran code 12056
90.58.4 lisp code 12056
90.59 sisnan 12056
90.59.1 Axiom unit tests 12056
90.59.2 Axiom help page 12056
90.59.3 fortran code 12057
90.59.4 lisp code 12058
90.60 slabad 12058
90.60.1 Axiom unit tests 12058
90.60.2 Axiom help page 12059
90.60.3 fortran code 12059
90.60.4 lisp code 12060
90.61 slacpy 12061
90.61.1 Axiom unit tests 12061
90.61.2 Axiom help page 12061
90.61.3 fortran code 12062
90.61.4 lisp code 12064
90.62 sladiv 12065
90.62.1 Axiom unit tests 12065
90.62.2 Axiom help page 12066
90.62.3 fortran code 12067
90.62.4 lisp code 12070
90.63 slae2 12073
90.63.1 Axiom unit tests 12073
90.63.2 Axiom help page 12074
90.63.3 fortran code 12075
90.63.4 lisp code 12077

90.64slaebz 12078
90.64.1 Axiom unit tests 12078
90.64.2 Axiom help page 12078
90.64.3 fortran code 12082
90.64.4 lisp code 12089
90.65slaev2 12098
90.65.1 Axiom unit tests 12098
90.65.2 Axiom help page 12098
90.65.3 fortran code 12100
90.65.4 lisp code 12102
90.66slag2d 12104
90.66.1 Axiom unit tests 12104
90.66.2 Axiom help page 12104
90.66.3 fortran code 12105
90.66.4 lisp code 12106
90.67slagts 12107
90.67.1 Axiom unit tests 12107
90.67.2 Axiom help page 12108
90.67.3 fortran code 12110
90.67.4 lisp code 12114
90.68slaisnan 12120
90.68.1 Axiom unit tests 12120
90.68.2 Axiom help page 12121
90.68.3 fortran code 12121
90.68.4 lisp code 12122
90.69slamc1 12123
90.69.1 Axiom unit tests 12123
90.69.2 Axiom help page 12123
90.69.3 fortran code 12124
90.69.4 lisp code 12124
90.70slamc2 12124
90.70.1 Axiom unit tests 12124
90.70.2 Axiom help page 12124
90.70.3 fortran code 12125
90.70.4 lisp code 12125
90.71slamc3 12126
90.71.1 Axiom unit tests 12126
90.71.2 Axiom help page 12126
90.71.3 fortran code 12127
90.71.4 lisp code 12127
90.72slamch 12127
90.72.1 Axiom unit tests 12127
90.72.2 Axiom help page 12127
90.72.3 fortran code 12128
90.72.4 lisp code 12128
90.73slaneg 12129

90.73.1 Axiom unit tests . . . 12129
90.73.2 Axiom help page . . . 12129
90.73.3 fortran code . . . 12130
90.73.4 lisp code . . . 12132
90.74slanst . . . 12136
90.74.1 Axiom unit tests . . . 12136
90.74.2 Axiom help page . . . 12136
90.74.3 fortran code . . . 12137
90.74.4 lisp code . . . 12139
90.75slapy2 . . . 12142
90.75.1 Axiom unit tests . . . 12142
90.75.2 Axiom help page . . . 12142
90.75.3 fortran code . . . 12143
90.75.4 lisp code . . . 12144
90.76slapy3 . . . 12144
90.76.1 Axiom unit tests . . . 12144
90.76.2 Axiom help page . . . 12145
90.76.3 fortran code . . . 12145
90.76.4 lisp code . . . 12146
90.77slarnv . . . 12147
90.77.1 Axiom unit tests . . . 12147
90.77.2 Axiom help page . . . 12147
90.77.3 fortran code . . . 12149
90.77.4 lisp code . . . 12150
90.78slarra . . . 12152
90.78.1 Axiom unit tests . . . 12152
90.78.2 Axiom help page . . . 12152
90.78.3 fortran code . . . 12154
90.78.4 lisp code . . . 12155
90.79slarrb . . . 12157
90.79.1 Axiom unit tests . . . 12157
90.79.2 Axiom help page . . . 12157
90.79.3 fortran code . . . 12160
90.79.4 lisp code . . . 12164
90.80slarrc . . . 12168
90.80.1 Axiom unit tests . . . 12168
90.80.2 Axiom help page . . . 12169
90.80.3 fortran code . . . 12170
90.80.4 lisp code . . . 12172
90.81slarrd . . . 12175
90.81.1 Axiom unit tests . . . 12175
90.81.2 Axiom help page . . . 12175
90.81.3 fortran code . . . 12179
90.81.4 lisp code . . . 12189
90.82slarre . . . 12203
90.82.1 Axiom unit tests . . . 12203

90.82.2 Axiom help page . . . 12203
90.82.3 fortran code . . . 12207
90.82.4 lisp code . . . 12218
90.83 slarrf . . . 12234
90.83.1 Axiom unit tests . . . 12234
90.83.2 Axiom help page . . . 12235
90.83.3 fortran code . . . 12237
90.83.4 lisp code . . . 12243
90.84 slarrj . . . 12250
90.84.1 Axiom unit tests . . . 12250
90.84.2 Axiom help page . . . 12250
90.84.3 fortran code . . . 12252
90.84.4 lisp code . . . 12256
90.85 slarrk . . . 12261
90.85.1 Axiom unit tests . . . 12261
90.85.2 Axiom help page . . . 12261
90.85.3 fortran code . . . 12263
90.85.4 lisp code . . . 12265
90.86 slarrr . . . 12267
90.86.1 Axiom unit tests . . . 12267
90.86.2 Axiom help page . . . 12268
90.86.3 fortran code . . . 12269
90.86.4 lisp code . . . 12271
90.87 slartg . . . 12273
90.87.1 Axiom unit tests . . . 12273
90.87.2 Axiom help page . . . 12273
90.87.3 fortran code . . . 12274
90.87.4 lisp code . . . 12276
90.88 slartgp . . . 12278
90.88.1 Axiom unit tests . . . 12278
90.88.2 Axiom help page . . . 12278
90.88.3 fortran code . . . 12280
90.88.4 lisp code . . . 12282
90.89 slaruv . . . 12283
90.89.1 Axiom unit tests . . . 12283
90.89.2 Axiom help page . . . 12284
90.89.3 fortran code . . . 12285
90.89.4 lisp code . . . 12292
90.90 slas2 . . . 12299
90.90.1 Axiom unit tests . . . 12299
90.90.2 Axiom help page . . . 12300
90.90.3 fortran code . . . 12301
90.90.4 lisp code . . . 12302
90.91 slascl . . . 12304
90.91.1 Axiom unit tests . . . 12304
90.91.2 Axiom help page . . . 12304

90.91.3 fortran code . . . 12306
90.91.4 lisp code . . . 12310
90.92 slasd0 . . . 12316
90.92.1 Axiom unit tests . . . 12316
90.92.2 Axiom help page . . . 12316
90.92.3 fortran code . . . 12318
90.92.4 lisp code . . . 12321
90.93 slasd1 . . . 12326
90.93.1 Axiom unit tests . . . 12326
90.93.2 Axiom help page . . . 12326
90.93.3 fortran code . . . 12329
90.93.4 lisp code . . . 12331
90.94 slasd2 . . . 12335
90.94.1 Axiom unit tests . . . 12335
90.94.2 Axiom help page . . . 12335
90.94.3 fortran code . . . 12339
90.94.4 lisp code . . . 12346
90.95 slasd3 . . . 12355
90.95.1 Axiom unit tests . . . 12355
90.95.2 Axiom help page . . . 12355
90.95.3 fortran code . . . 12358
90.95.4 lisp code . . . 12363
90.96 slasd4 . . . 12374
90.96.1 Axiom unit tests . . . 12374
90.96.2 Axiom help page . . . 12375
90.96.3 fortran code . . . 12377
90.96.4 lisp code . . . 12394
90.97 slasd5 . . . 12419
90.97.1 Axiom unit tests . . . 12419
90.97.2 Axiom help page . . . 12420
90.97.3 fortran code . . . 12421
90.97.4 lisp code . . . 12423
90.98 slasd6 . . . 12427
90.98.1 Axiom unit tests . . . 12427
90.98.2 Axiom help page . . . 12427
90.98.3 fortran code . . . 12432
90.98.4 lisp code . . . 12434
90.99 slasd7 . . . 12438
90.99.1 Axiom unit tests . . . 12438
90.99.2 Axiom help page . . . 12439
90.99.3 fortran code . . . 12442
90.99.4 lisp code . . . 12448
90.100 slasd8 . . . 12455
90.100.1 Axiom unit tests . . . 12455
90.100.2 Axiom help page . . . 12456
90.100.3 fortran code . . . 12458

90.100.4 lisp code . . . 12461
90.101 slasda . . . 12468
90.101.1 Axiom unit tests . . . 12468
90.101.2 Axiom help page . . . 12468
90.101.3 fortran code . . . 12472
90.101.4 lisp code . . . 12476
90.102 slasdq . . . 12488
90.102.1 Axiom unit tests . . . 12488
90.102.2 Axiom help page . . . 12489
90.102.3 fortran code . . . 12491
90.102.4 lisp code . . . 12495
90.103 slasdt . . . 12502
90.103.1 Axiom unit tests . . . 12502
90.103.2 Axiom help page . . . 12502
90.103.3 fortran code . . . 12503
90.103.4 lisp code . . . 12505
90.104 slaset . . . 12507
90.104.1 Axiom unit tests . . . 12507
90.104.2 Axiom help page . . . 12507
90.104.3 fortran code . . . 12509
90.104.4 lisp code . . . 12510
90.105 slasr . . . 12512
90.105.1 Axiom unit tests . . . 12512
90.105.2 Axiom help page . . . 12512
90.105.3 fortran code . . . 12515
90.105.4 lisp code . . . 12520
90.106 slassq . . . 12531
90.106.1 Axiom unit tests . . . 12531
90.106.2 Axiom help page . . . 12531
90.106.3 fortran code . . . 12532
90.106.4 lisp code . . . 12534
90.107 slasv2 . . . 12535
90.107.1 Axiom unit tests . . . 12535
90.107.2 Axiom help page . . . 12535
90.107.3 fortran code . . . 12537
90.107.4 lisp code . . . 12541
90.108 sstiee . . . 12543
90.108.1 Axiom unit tests . . . 12543
90.108.2 Axiom help page . . . 12543
90.108.3 fortran code . . . 12544
90.108.4 lisp code . . . 12544
90.109 xerbla_array . . . 12544
90.109.1 Axiom unit tests . . . 12544
90.109.2 Axiom help page . . . 12544
90.109.3 fortran code . . . 12545
90.109.4 lisp code . . . 12546

90.110 cbbcsd - CS Decomposition of Unitary Matrix . . . 12546
90.110.1 Axiom unit tests . . . 12546
90.110.2 Axiom help page . . . 12547
90.110.3 fortran code . . . 12551
90.110.4 lisp code . . . 12579
90.111 cbdsqr - compute singular values from an SVD . . . 12624
90.111.1 Axiom unit tests . . . 12624
90.111.2 Axiom help page . . . 12625
90.111.3 fortran code . . . 12628
90.111.4 lisp code . . . 12651
90.112 cgbbrd - reduce complex band matrix to real upper bidiagonal . . . 12671
90.112.1 Axiom unit tests . . . 12671
90.112.2 Axiom help page . . . 12671
90.112.3 fortran code . . . 12674
90.112.4 lisp code . . . 12688
90.113 dbdsdc . . . 12703
90.113.1 Axiom unit tests . . . 12703
90.113.2 Axiom help page . . . 12703
90.113.3 fortran code . . . 12707
90.113.4 lisp code . . . 12719
90.114 dbdsqr . . . 12731
90.114.1 Axiom unit tests . . . 12731
90.114.2 Axiom help page . . . 12731
90.114.3 fortran code . . . 12734
90.114.4 lisp code . . . 12758
90.115 ddisna . . . 12778
90.115.1 Axiom unit tests . . . 12778
90.115.2 Axiom help page . . . 12778
90.115.3 fortran code . . . 12780
90.115.4 lisp code . . . 12785
90.116 dgebak . . . 12787
90.116.1 Axiom unit tests . . . 12787
90.116.2 Axiom help page . . . 12788
90.116.3 fortran code . . . 12789
90.116.4 lisp code . . . 12795
90.117 dgebal . . . 12799
90.117.1 Axiom unit tests . . . 12799
90.117.2 Axiom help page . . . 12799
90.117.3 fortran code . . . 12801
90.117.4 lisp code . . . 12810
90.118 dgebd2 . . . 12815
90.118.1 Axiom unit tests . . . 12815
90.118.2 Axiom help page . . . 12816
90.118.3 fortran code . . . 12818
90.118.4 lisp code . . . 12823
90.119 dgebrd . . . 12827

90.119.1 Axiom unit tests . . . 12827
90.119.2 Axiom help page . . . 12827
90.119.3 fortran code . . . 12830
90.119.4 lisp code . . . 12835
90.120 dgeev . . . 12840
90.120.1 Axiom unit tests . . . 12840
90.120.2 Axiom help page . . . 12840
90.120.3 fortran code . . . 12842
90.120.4 lisp code . . . 12854
90.121 dgeevx . . . 12868
90.121.1 Axiom unit tests . . . 12868
90.121.2 Axiom help page . . . 12868
90.121.3 fortran code . . . 12872
90.121.4 lisp code . . . 12886
90.122 dgehd2 . . . 12902
90.122.1 Axiom unit tests . . . 12902
90.122.2 Axiom help page . . . 12902
90.122.3 fortran code . . . 12904
90.122.4 lisp code . . . 12907
90.123 dgehrd . . . 12909
90.123.1 Axiom unit tests . . . 12909
90.123.2 Axiom help page . . . 12909
90.123.3 fortran code . . . 12911
90.123.4 lisp code . . . 12918
90.124 dgelq2 . . . 12923
90.124.1 Axiom unit tests . . . 12923
90.124.2 Axiom help page . . . 12923
90.124.3 fortran code . . . 12925
90.124.4 lisp code . . . 12927
90.125 dgelqf . . . 12929
90.125.1 Axiom unit tests . . . 12929
90.125.2 Axiom help page . . . 12929
90.125.3 fortran code . . . 12931
90.125.4 lisp code . . . 12936
90.126 dgeqr2 . . . 12939
90.126.1 Axiom unit tests . . . 12939
90.126.2 Axiom help page . . . 12939
90.126.3 fortran code . . . 12941
90.126.4 lisp code . . . 12943
90.127 dgeqrf . . . 12945
90.127.1 Axiom unit tests . . . 12945
90.127.2 Axiom help page . . . 12945
90.127.3 fortran code . . . 12947
90.127.4 lisp code . . . 12952
90.128 dgesdd . . . 12955
90.128.1 Axiom unit tests . . . 12955

90.128.2 Axiom help page . . . 12955
90.128.3 fortran code . . . 12958
90.128.4 lisp code . . . 13003
90.129 dgesvd . . . 13074
90.129.1 Axiom unit tests . . . 13074
90.129.2 Axiom help page . . . 13074
90.129.3 fortran code . . . 13077
90.129.4 lisp code . . . 13199
90.130 dgesv . . . 13320
90.130.1 Axiom unit tests . . . 13320
90.130.2 Axiom help page . . . 13321
90.130.3 fortran code . . . 13322
90.130.4 lisp code . . . 13324
90.131 dgetf2 . . . 13325
90.131.1 Axiom unit tests . . . 13325
90.131.2 Axiom help page . . . 13326
90.131.3 fortran code . . . 13327
90.131.4 lisp code . . . 13331
90.132 dgetrf . . . 13333
90.132.1 Axiom unit tests . . . 13333
90.132.2 Axiom help page . . . 13333
90.132.3 fortran code . . . 13335
90.132.4 lisp code . . . 13339
90.133 dgetrs . . . 13342
90.133.1 Axiom unit tests . . . 13342
90.133.2 Axiom help page . . . 13342
90.133.3 fortran code . . . 13344
90.133.4 lisp code . . . 13348
90.134 dhseqr . . . 13350
90.134.1 Axiom unit tests . . . 13350
90.134.2 Axiom help page . . . 13350
90.134.3 fortran code . . . 13353
90.134.4 lisp code . . . 13364
90.135 disnan . . . 13369
90.135.1 Axiom unit tests . . . 13369
90.135.2 Axiom help page . . . 13370
90.135.3 fortran code . . . 13370
90.135.4 lisp code . . . 13371
90.136 dlabad . . . 13372
90.136.1 Axiom unit tests . . . 13372
90.136.2 Axiom help page . . . 13372
90.136.3 fortran code . . . 13373
90.136.4 lisp code . . . 13374
90.137 dlabrd . . . 13375
90.137.1 Axiom unit tests . . . 13375
90.137.2 Axiom help page . . . 13375

90.137.3 fortran code . . . 13378
90.137.4 lisp code . . . 13384
90.138 dlacon . . . 13397
90.138.1 Axiom unit tests . . . 13397
90.138.2 Axiom help page . . . 13397
90.138.3 fortran code . . . 13399
90.138.4 lisp code . . . 13405
90.139 dlacpy . . . 13408
90.139.1 Axiom unit tests . . . 13408
90.139.2 Axiom help page . . . 13408
90.139.3 fortran code . . . 13410
90.139.4 lisp code . . . 13412
90.140 dladiv . . . 13413
90.140.1 Axiom unit tests . . . 13413
90.140.2 Axiom help page . . . 13413
90.140.3 fortran code . . . 13414
90.140.4 lisp code . . . 13418
90.141 dlaed6 . . . 13419
90.141.1 Axiom unit tests . . . 13419
90.141.2 Axiom help page . . . 13420
90.141.3 fortran code . . . 13421
90.141.4 lisp code . . . 13431
90.142 dlaexc . . . 13436
90.142.1 Axiom unit tests . . . 13436
90.142.2 Axiom help page . . . 13437
90.142.3 fortran code . . . 13438
90.142.4 lisp code . . . 13449
90.143 dlahqr . . . 13460
90.143.1 Axiom unit tests . . . 13460
90.143.2 Axiom help page . . . 13460
90.143.3 fortran code . . . 13462
90.143.4 lisp code . . . 13476
90.144 dlahrd DEPRECATED see dlahr2 . . . 13489
90.144.1 Axiom unit tests . . . 13489
90.144.2 Axiom help page . . . 13490
90.144.3 fortran code . . . 13492
90.144.4 lisp code . . . 13494
90.145 dlaisnan . . . 13497
90.145.1 Axiom unit tests . . . 13497
90.145.2 Axiom help page . . . 13498
90.145.3 fortran code . . . 13499
90.145.4 lisp code . . . 13499
90.146 dlaln2 . . . 13500
90.146.1 Axiom unit tests . . . 13500
90.146.2 Axiom help page . . . 13500
90.146.3 fortran code . . . 13503

90.146.4 lisp code . . . 13510
90.147 dlamch . . . 13524
90.147.1 Axiom unit tests . . . 13524
90.147.2 Axiom help page . . . 13524
90.147.3 fortran code . . . 13525
90.147.4 lisp code . . . 13527
90.148 dlamc1 . . . 13530
90.148.1 Axiom unit tests . . . 13530
90.148.2 Axiom help page . . . 13531
90.148.3 fortran code . . . 13532
90.148.4 lisp code . . . 13535
90.149 dlamc2 . . . 13536
90.149.1 Axiom unit tests . . . 13536
90.149.2 Axiom help page . . . 13536
90.149.3 fortran code . . . 13538
90.149.4 lisp code . . . 13542
90.150 dlamc3 . . . 13545
90.150.1 Axiom unit tests . . . 13545
90.150.2 Axiom help page . . . 13545
90.150.3 fortran code . . . 13546
90.150.4 lisp code . . . 13547
90.151 dlamc4 . . . 13547
90.151.1 Axiom unit tests . . . 13547
90.151.2 Axiom help page . . . 13548
90.151.3 fortran code . . . 13548
90.151.4 lisp code . . . 13550
90.152 dlamc5 . . . 13551
90.152.1 Axiom unit tests . . . 13551
90.152.2 Axiom help page . . . 13551
90.152.3 fortran code . . . 13552
90.152.4 lisp code . . . 13555
90.153 dlamrg . . . 13556
90.153.1 Axiom unit tests . . . 13556
90.153.2 Axiom help page . . . 13556
90.153.3 fortran code . . . 13557
90.153.4 lisp code . . . 13559
90.154 dlange . . . 13560
90.154.1 Axiom unit tests . . . 13560
90.154.2 Axiom help page . . . 13560
90.154.3 fortran code . . . 13562
90.154.4 lisp code . . . 13564
90.155 dlanhs . . . 13566
90.155.1 Axiom unit tests . . . 13566
90.155.2 Axiom help page . . . 13567
90.155.3 fortran code . . . 13568
90.155.4 lisp code . . . 13570

90.156 dlanst 13573
90.156.1 Axiom unit tests 13573
90.156.2 Axiom help page 13574
90.156.3 fortran code 13575
90.156.4 lisp code 13577
90.157 dlanv2 13579
90.157.1 Axiom unit tests 13579
90.157.2 Axiom help page 13580
90.157.3 fortran code 13581
90.157.4 lisp code 13584
90.158 dlapy2 13586
90.158.1 Axiom unit tests 13586
90.158.2 Axiom help page 13586
90.158.3 fortran code 13587
90.158.4 lisp code 13588
90.159 dlapy3 13588
90.159.1 Axiom unit tests 13588
90.159.2 Axiom help page 13589
90.159.3 fortran code 13590
90.159.4 lisp code 13591
90.160 dlaqtr 13591
90.160.1 Axiom unit tests 13591
90.160.2 Axiom help page 13592
90.160.3 fortran code 13594
90.160.4 lisp code 13605
90.161 dlarfb 13622
90.161.1 Axiom unit tests 13622
90.161.2 Axiom help page 13622
90.161.3 fortran code 13624
90.161.4 lisp code 13634
90.162 dlarfg 13652
90.162.1 Axiom unit tests 13652
90.162.2 Axiom help page 13653
90.162.3 fortran code 13654
90.162.4 lisp code 13656
90.163 dlarf 13657
90.163.1 Axiom unit tests 13657
90.163.2 Axiom help page 13657
90.163.3 fortran code 13659
90.163.4 lisp code 13660
90.164 dlarft 13663
90.164.1 Axiom unit tests 13663
90.164.2 Axiom help page 13663
90.164.3 fortran code 13665
90.164.4 lisp code 13668
90.165 dlarfx 13674

90.165.1 Axiom unit tests . . . 13674
90.165.2 Axiom help page . . . 13674
90.165.3 fortran code . . . 13676
90.165.4 lisp code . . . 13687
90.166 dlartg . . . 13711
90.166.1 Axiom unit tests . . . 13711
90.166.2 Axiom help page . . . 13712
90.166.3 fortran code . . . 13713
90.166.4 lisp code . . . 13715
90.167 dlas2 . . . 13716
90.167.1 Axiom unit tests . . . 13716
90.167.2 Axiom help page . . . 13717
90.167.3 fortran code . . . 13718
90.167.4 lisp code . . . 13720
90.168 dlascl . . . 13721
90.168.1 Axiom unit tests . . . 13721
90.168.2 Axiom help page . . . 13721
90.168.3 fortran code . . . 13723
90.168.4 lisp code . . . 13727
90.169 dlasd0 . . . 13732
90.169.1 Axiom unit tests . . . 13732
90.169.2 Axiom help page . . . 13732
90.169.3 fortran code . . . 13734
90.169.4 lisp code . . . 13737
90.170 dlasd1 . . . 13742
90.170.1 Axiom unit tests . . . 13742
90.170.2 Axiom help page . . . 13742
90.170.3 fortran code . . . 13745
90.170.4 lisp code . . . 13747
90.171 dlasd2 . . . 13750
90.171.1 Axiom unit tests . . . 13750
90.171.2 Axiom help page . . . 13750
90.171.3 fortran code . . . 13754
90.171.4 lisp code . . . 13761
90.172 dlasd3 . . . 13769
90.172.1 Axiom unit tests . . . 13769
90.172.2 Axiom help page . . . 13769
90.172.3 fortran code . . . 13772
90.172.4 lisp code . . . 13777
90.173 dlasd4 . . . 13787
90.173.1 Axiom unit tests . . . 13787
90.173.2 Axiom help page . . . 13788
90.173.3 fortran code . . . 13790
90.173.4 lisp code . . . 13805
90.174 dlasd5 . . . 13830
90.174.1 Axiom unit tests . . . 13830

90.174.2 Axiom help page . . . 13831
90.174.3 fortran code . . . 13832
90.174.4 lisp code . . . 13834
90.175 dlasd6 . . . 13838
90.175.1 Axiom unit tests . . . 13838
90.175.2 Axiom help page . . . 13838
90.175.3 fortran code . . . 13842
90.175.4 lisp code . . . 13845
90.176 dlasd7 . . . 13848
90.176.1 Axiom unit tests . . . 13848
90.176.2 Axiom help page . . . 13848
90.176.3 fortran code . . . 13851
90.176.4 lisp code . . . 13857
90.177 dlasd8 . . . 13864
90.177.1 Axiom unit tests . . . 13864
90.177.2 Axiom help page . . . 13864
90.177.3 fortran code . . . 13866
90.177.4 lisp code . . . 13869
90.178 dlasda . . . 13875
90.178.1 Axiom unit tests . . . 13875
90.178.2 Axiom help page . . . 13875
90.178.3 fortran code . . . 13879
90.178.4 lisp code . . . 13883
90.179 dlasdq . . . 13895
90.179.1 Axiom unit tests . . . 13895
90.179.2 Axiom help page . . . 13895
90.179.3 fortran code . . . 13898
90.179.4 lisp code . . . 13902
90.180 dlasdt . . . 13907
90.180.1 Axiom unit tests . . . 13907
90.180.2 Axiom help page . . . 13908
90.180.3 fortran code . . . 13909
90.180.4 lisp code . . . 13910
90.181 dlaset . . . 13912
90.181.1 Axiom unit tests . . . 13912
90.181.2 Axiom help page . . . 13912
90.181.3 fortran code . . . 13914
90.181.4 lisp code . . . 13915
90.182 dlasq1 . . . 13917
90.182.1 Axiom unit tests . . . 13917
90.182.2 Axiom help page . . . 13917
90.182.3 fortran code . . . 13918
90.182.4 lisp code . . . 13920
90.183 dlasq2 . . . 13924
90.183.1 Axiom unit tests . . . 13924
90.183.2 Axiom help page . . . 13924

90.183.3 fortran code . . . 13925
90.183.4 lisp code . . . 13933
90.184 dlasq3 . . . 13950
90.184.1 Axiom unit tests . . . 13950
90.184.2 Axiom help page . . . 13951
90.184.3 fortran code . . . 13952
90.184.4 lisp code . . . 13957
90.185 dlasq4 . . . 13966
90.185.1 Axiom unit tests . . . 13966
90.185.2 Axiom help page . . . 13966
90.185.3 fortran code . . . 13967
90.185.4 lisp code . . . 13973
90.186 dlasq5 . . . 13980
90.186.1 Axiom unit tests . . . 13980
90.186.2 Axiom help page . . . 13980
90.186.3 fortran code . . . 13982
90.186.4 lisp code . . . 13985
90.187 dlasq6 . . . 13996
90.187.1 Axiom unit tests . . . 13996
90.187.2 Axiom help page . . . 13996
90.187.3 fortran code . . . 13998
90.187.4 lisp code . . . 14000
90.188 dlasr . . . 14006
90.188.1 Axiom unit tests . . . 14006
90.188.2 Axiom help page . . . 14006
90.188.3 fortran code . . . 14008
90.188.4 lisp code . . . 14013
90.189 dlasrt . . . 14024
90.189.1 Axiom unit tests . . . 14024
90.189.2 Axiom help page . . . 14024
90.189.3 fortran code . . . 14025
90.189.4 lisp code . . . 14029
90.190 dlassq . . . 14033
90.190.1 Axiom unit tests . . . 14033
90.190.2 Axiom help page . . . 14033
90.190.3 fortran code . . . 14035
90.190.4 lisp code . . . 14036
90.191 dlasv2 . . . 14037
90.191.1 Axiom unit tests . . . 14037
90.191.2 Axiom help page . . . 14037
90.191.3 fortran code . . . 14039
90.191.4 lisp code . . . 14042
90.192 dlaswp . . . 14044
90.192.1 Axiom unit tests . . . 14044
90.192.2 Axiom help page . . . 14044
90.192.3 fortran code . . . 14046

90.192.4 lisp code . . . 14047
90.193 dlasy2 . . . 14049
90.193.1 Axiom unit tests . . . 14049
90.193.2 Axiom help page . . . 14049
90.193.3 fortran code . . . 14051
90.193.4 lisp code . . . 14057
90.194 dorg2r . . . 14067
90.194.1 Axiom unit tests . . . 14067
90.194.2 Axiom help page . . . 14068
90.194.3 fortran code . . . 14069
90.194.4 lisp code . . . 14071
90.195 dorgbr . . . 14072
90.195.1 Axiom unit tests . . . 14072
90.195.2 Axiom help page . . . 14073
90.195.3 fortran code . . . 14075
90.195.4 lisp code . . . 14078
90.196 dorghr . . . 14082
90.196.1 Axiom unit tests . . . 14082
90.196.2 Axiom help page . . . 14083
90.196.3 fortran code . . . 14084
90.196.4 lisp code . . . 14086
90.197 dorgl2 . . . 14089
90.197.1 Axiom unit tests . . . 14089
90.197.2 Axiom help page . . . 14089
90.197.3 fortran code . . . 14091
90.197.4 lisp code . . . 14093
90.198 dorglq . . . 14094
90.198.1 Axiom unit tests . . . 14094
90.198.2 Axiom help page . . . 14095
90.198.3 fortran code . . . 14096
90.198.4 lisp code . . . 14099
90.199 dorgqr . . . 14103
90.199.1 Axiom unit tests . . . 14103
90.199.2 Axiom help page . . . 14104
90.199.3 fortran code . . . 14105
90.199.4 lisp code . . . 14108
90.200 dorm2r . . . 14112
90.200.1 Axiom unit tests . . . 14112
90.200.2 Axiom help page . . . 14112
90.200.3 fortran code . . . 14114
90.200.4 lisp code . . . 14117
90.201 dormbr . . . 14119
90.201.1 Axiom unit tests . . . 14119
90.201.2 Axiom help page . . . 14119
90.201.3 fortran code . . . 14122
90.201.4 lisp code . . . 14125

90.202 dorml2 . . . 14130
90.202.1 Axiom unit tests . . . 14130
90.202.2 Axiom help page . . . 14130
90.202.3 fortran code . . . 14132
90.202.4 lisp code . . . 14135
90.203 dormlq . . . 14137
90.203.1 Axiom unit tests . . . 14137
90.203.2 Axiom help page . . . 14137
90.203.3 fortran code . . . 14139
90.203.4 lisp code . . . 14143
90.204 dormqr . . . 14146
90.204.1 Axiom unit tests . . . 14146
90.204.2 Axiom help page . . . 14147
90.204.3 fortran code . . . 14149
90.204.4 lisp code . . . 14152
90.205 dtrevc . . . 14156
90.205.1 Axiom unit tests . . . 14156
90.205.2 Axiom help page . . . 14156
90.205.3 fortran code . . . 14160
90.205.4 lisp code . . . 14176
90.206 dtrexc . . . 14210
90.206.1 Axiom unit tests . . . 14210
90.206.2 Axiom help page . . . 14210
90.206.3 fortran code . . . 14212
90.206.4 lisp code . . . 14218
90.207 dtrsna . . . 14224
90.207.1 Axiom unit tests . . . 14224
90.207.2 Axiom help page . . . 14224
90.207.3 fortran code . . . 14228
90.207.4 lisp code . . . 14234
90.208 ieeck . . . 14246
90.208.1 Axiom unit tests . . . 14246
90.208.2 Axiom help page . . . 14246
90.208.3 fortran code . . . 14247
90.208.4 lisp code . . . 14249
90.209 ilaenv . . . 14250
90.209.1 Axiom unit tests . . . 14250
90.209.2 Axiom help page . . . 14251
90.209.3 fortran code . . . 14253
90.209.4 lisp code . . . 14262
90.210 ilazlc . . . 14268
90.210.1 Axiom unit tests . . . 14268
90.210.2 Axiom help page . . . 14268
90.210.3 fortran code . . . 14269
90.210.4 lisp code . . . 14270
90.211 ilazlr . . . 14271

90.211.1 Axiom unit tests . . . 14271
90.211.2 Axiom help page . . . 14271
90.211.3 fortran code . . . 14272
90.211.4 lisp code . . . 14273
90.212 gebak . . . 14274
90.212.1 Axiom unit tests . . . 14274
90.212.2 Axiom help page . . . 14275
90.212.3 fortran code . . . 14277
90.212.4 lisp code . . . 14279
90.213 gebal . . . 14283
90.213.1 Axiom unit tests . . . 14283
90.213.2 Axiom help page . . . 14284
90.213.3 fortran code . . . 14286
90.213.4 lisp code . . . 14291
90.214 geev . . . 14297
90.214.1 Axiom unit tests . . . 14297
90.214.2 Axiom help page . . . 14297
90.214.3 fortran code . . . 14300
90.214.4 lisp code . . . 14306
90.215 gehd2 . . . 14317
90.215.1 Axiom unit tests . . . 14317
90.215.2 Axiom help page . . . 14318
90.215.3 fortran code . . . 14320
90.215.4 lisp code . . . 14321
90.216 hseqr . . . 14323
90.216.1 Axiom unit tests . . . 14323
90.216.2 Axiom help page . . . 14324
90.216.3 fortran code . . . 14328
90.216.4 lisp code . . . 14332
90.217 lacgv . . . 14338
90.217.1 Axiom unit tests . . . 14338
90.217.2 Axiom help page . . . 14338
90.217.3 fortran code . . . 14339
90.217.4 lisp code . . . 14340
90.218 lacpy . . . 14341
90.218.1 Axiom unit tests . . . 14341
90.218.2 Axiom help page . . . 14341
90.218.3 fortran code . . . 14343
90.218.4 lisp code . . . 14344
90.219 ladiv . . . 14346
90.219.1 Axiom unit tests . . . 14346
90.219.2 Axiom help page . . . 14346
90.219.3 fortran code . . . 14347
90.219.4 lisp code . . . 14348
90.220 lahqr . . . 14348
90.220.1 Axiom unit tests . . . 14348

90.220.2 Axiom help page . . . 14348
90.220.3 fortran code . . . 14351
90.220.4 lisp code . . . 14358
90.221 zlahr2 . . . 14369
90.221.1 Axiom unit tests . . . 14369
90.221.2 Axiom help page . . . 14370
90.221.3 fortran code . . . 14373
90.221.4 lisp code . . . 14376
90.222 zlange . . . 14381
90.222.1 Axiom unit tests . . . 14381
90.222.2 Axiom help page . . . 14382
90.222.3 fortran code . . . 14383
90.222.4 lisp code . . . 14385
90.223 zlaqr0 . . . 14388
90.223.1 Axiom unit tests . . . 14388
90.223.2 Axiom help page . . . 14389
90.223.3 fortran code . . . 14392
90.223.4 lisp code . . . 14401
90.224 zlaqr1 . . . 14413
90.224.1 Axiom unit tests . . . 14413
90.224.2 Axiom help page . . . 14413
90.224.3 fortran code . . . 14414
90.224.4 lisp code . . . 14416
90.225 zlaqr2 . . . 14419
90.225.1 Axiom unit tests . . . 14419
90.225.2 Axiom help page . . . 14419
90.225.3 fortran code . . . 14423
90.225.4 lisp code . . . 14429
90.226 zlaqr3 . . . 14438
90.226.1 Axiom unit tests . . . 14438
90.226.2 Axiom help page . . . 14438
90.226.3 fortran code . . . 14442
90.226.4 lisp code . . . 14448
90.227 zlaqr4 . . . 14458
90.227.1 Axiom unit tests . . . 14458
90.227.2 Axiom help page . . . 14458
90.227.3 fortran code . . . 14462
90.227.4 lisp code . . . 14470
90.228 zlaqr5 . . . 14481
90.228.1 Axiom unit tests . . . 14481
90.228.2 Axiom help page . . . 14482
90.228.3 fortran code . . . 14485
90.228.4 lisp code . . . 14498
90.229 zlarfb . . . 14529
90.229.1 Axiom unit tests . . . 14529
90.229.2 Axiom help page . . . 14530

90.229.3 fortran code . . . 14533
90.229.4 lisp code . . . 14544
90.230 larf . . . 14563
90.230.1 Axiom unit tests . . . 14563
90.230.2 Axiom help page . . . 14563
90.230.3 fortran code . . . 14565
90.230.4 lisp code . . . 14567
90.231 larfg . . . 14569
90.231.1 Axiom unit tests . . . 14569
90.231.2 Axiom help page . . . 14569
90.231.3 fortran code . . . 14571
90.231.4 lisp code . . . 14573
90.232 larft . . . 14575
90.232.1 Axiom unit tests . . . 14575
90.232.2 Axiom help page . . . 14575
90.232.3 fortran code . . . 14578
90.232.4 lisp code . . . 14581
90.233 lartg . . . 14587
90.233.1 Axiom unit tests . . . 14587
90.233.2 Axiom help page . . . 14588
90.233.3 fortran code . . . 14589
90.233.4 lisp code . . . 14592
90.234 lascl . . . 14595
90.234.1 Axiom unit tests . . . 14595
90.234.2 Axiom help page . . . 14595
90.234.3 fortran code . . . 14597
90.234.4 lisp code . . . 14602
90.235 laset . . . 14607
90.235.1 Axiom unit tests . . . 14607
90.235.2 Axiom help page . . . 14607
90.235.3 fortran code . . . 14609
90.235.4 lisp code . . . 14611
90.236 lassq . . . 14612
90.236.1 Axiom unit tests . . . 14612
90.236.2 Axiom help page . . . 14613
90.236.3 fortran code . . . 14614
90.236.4 lisp code . . . 14616
90.237 zlatrs . . . 14617
90.237.1 Axiom unit tests . . . 14617
90.237.2 Axiom help page . . . 14617
90.237.3 fortran code . . . 14621
90.237.4 lisp code . . . 14635
90.238 srot . . . 14650
90.238.1 Axiom unit tests . . . 14650
90.238.2 Axiom help page . . . 14650
90.238.3 fortran code . . . 14652

90.238.4 lisp code . . . 14653
90.239 ztrevc . . . 14654
90.239.1 Axiom unit tests . . . 14654
90.239.2 Axiom help page . . . 14654
90.239.3 fortran code . . . 14658
90.239.4 lisp code . . . 14663
90.240 ztrexc . . . 14672
90.240.1 Axiom unit tests . . . 14672
90.240.2 Axiom help page . . . 14672
90.240.3 fortran code . . . 14674
90.240.4 lisp code . . . 14677
90.241 zung2r . . . 14679
90.241.1 Axiom unit tests . . . 14679
90.241.2 Axiom help page . . . 14679
90.241.3 fortran code . . . 14681
90.241.4 lisp code . . . 14683
90.242 zunghr . . . 14684
90.242.1 Axiom unit tests . . . 14684
90.242.2 Axiom help page . . . 14685
90.242.3 fortran code . . . 14686
90.242.4 lisp code . . . 14689
90.243 zungqr . . . 14691
90.243.1 Axiom unit tests . . . 14691
90.243.2 Axiom help page . . . 14692
90.243.3 fortran code . . . 14694
90.243.4 lisp code . . . 14697
90.244 zunm2r . . . 14701
90.244.1 Axiom unit tests . . . 14701
90.244.2 Axiom help page . . . 14701
90.244.3 fortran code . . . 14704
90.244.4 lisp code . . . 14706
90.245 zunmhr . . . 14708
90.245.1 Axiom unit tests . . . 14708
90.245.2 Axiom help page . . . 14709
90.245.3 fortran code . . . 14711
90.245.4 lisp code . . . 14714
90.246 zunmqr . . . 14716
90.246.1 Axiom unit tests . . . 14716
90.246.2 Axiom help page . . . 14717
90.246.3 fortran code . . . 14719
90.246.4 lisp code . . . 14723

91 LAPACK tests **14729**

92 ISAAC Secure Random Number Generation 14743
92.0.5 Axiom help page . . . 14743
92.0.6 defstruct isaacCtx . . . 14745
92.0.7 defun generateNextIsaacBlock . . . 14747
92.0.8 defun rand32 . . . 14748
92.0.9 defun randBits . . . 14748
92.0.10 defmacro incfWrap32 . . . 14748
92.0.11 defmacro mix . . . 14749
92.0.12 defun scramble . . . 14751
92.0.13 defun initKernelSeed . . . 14752
92.0.14 defun initCommonLispRandomSeed . . . 14752
92.0.15 defun initNullSeed . . . 14753

93 Chunk collections 14755

Bibliography 14765

Index 14775

Volume 11: Axiom Browser

1 Overview **1**
Build Instructions . . . 1
The Makefile . . . 1
Building new pages . . . 2
Communicating with Axiom . . . 3
Handling statements with no free variables . . . 3
Handling statements with free variables . . . 3
Handling domain database lookups . . . 4
Handling)show domain . . . 4
Handling lisp expressions . . . 4
Handling expressions that have no output . . . 4
Defined Pages . . . 4
The Standard Layout . . . 15
Cascading Style Sheet . . . 16
Standard Style Sheet . . . 16
Menu style sheet . . . 18
standard head . . . 21
Javascript functions . . . 22
Show only mathml . . . 22
Show Full Answer . . . 23
Handle Free Variables . . . 24
axiom talker . . . 25
Pages . . . 26
axiomfonts.xhtml . . . 38
algebrapage.xhtml . . . 82
alggrouptheory.xhtml . . . 82
alggrouptheorygroup.xhtml . . . 83
alggrouptheoryrepa6.xhtml . . . 84
alggrouptheoryreptheory.xhtml . . . 87
algnumbertheory.xhtml . . . 88
algnumbertheorygalois.xhtml . . . 88
basiccommand.xhtml . . . 95
basiclimit.xhtml . . . 96
bcexpand.xhtml . . . 96
bcmatrix.xhtml . . . 98
calculus.xhtml . . . 102
calculuspage.xhtml . . . 103
calderivatives.xhtml . . . 104
calintegrals.xhtml . . . 107
callaplace.xhtml . . . 110
callimits.xhtml . . . 111
calmoreintegrals.xhtml . . . 114
calseries.xhtml . . . 118

calseries1.xhtml . . . 119
calseries2.xhtml . . . 121
calseries3.xhtml . . . 123
calseries4.xhtml . . . 124
calseries5.xhtml . . . 127
calseries6.xhtml . . . 129
calseries7.xhtml . . . 132
calseries8.xhtml . . . 133
cats.xhtml . . . 136
commandline.xhtml . . . 137
complexlimit.xhtml . . . 151
conversionfunctions.xhtml . . . 152
crytopage.xhtml . . . 155
crytoclass1.xhtml . . . 156
crytoclass2.xhtml . . . 160
crytoclass3.xhtml . . . 163
crytoclass4.xhtml . . . 167
crytoclass5.xhtml . . . 170
crytoclass6.xhtml . . . 173
crytoclass7.xhtml . . . 175
crytoclass8.xhtml . . . 178
crytoclass9.xhtml . . . 182
crytoclass10.xhtml . . . 185
crytoclass11.xhtml . . . 187
dbopbinary.xhtml . . . 190
dbcharacteristic.xhtml . . . 190
dbcomplexcomplex.xhtml . . . 190
dbcomplexconjugate.xhtml . . . 191
dbcomplexfactor.xhtml . . . 191
dbcomplexdoublefloat.xhtml . . . 191
dbcomplexfloat.xhtml . . . 192
dbcompleximag.xhtml . . . 192
dbcomplexnorm.xhtml . . . 192
dbcomplexreal.xhtml . . . 192
dbcomplexinteger.xhtml . . . 193
dbexpressioninteger.xhtml . . . 193
dbfractioninteger.xhtml . . . 193
dbfractionpolynomialinteger.xhtml . . . 193
dblookup.xhtml . . . 194
dbopacos.xhtml . . . 194
dbopacosh.xhtml . . . 194
dbopacot.xhtml . . . 194
dbopacoth.xhtml . . . 195
dbopacsc.xhtml . . . 195
dbopacsch.xhtml . . . 195
dbopaddmod.xhtml . . . 195

dbopairyai.xhtml . . . 196
dbopairybi.xhtml . . . 196
dbopapproximants.xhtml . . . 196
dbopasin.xhtml . . . 196
dbopasinh.xhtml . . . 197
dbopasec.xhtml . . . 197
dbopasech.xhtml . . . 197
dbopatan.xhtml . . . 197
dbopatanh.xhtml . . . 198
dbopbernoullib.xhtml . . . 198
dbopbesseli.xhtml . . . 198
dbopbesselj.xhtml . . . 198
dbopbesselk.xhtml . . . 199
dbopbessely.xhtml . . . 199
dbopbeta.xhtml . . . 199
dbopcardinalnumber.xhtml . . . 199
dbopchebyshevt.xhtml . . . 200
dbopchebyshevu.xhtml . . . 200
dbopcoefficient.xhtml . . . 200
dbopcoefficients.xhtml . . . 200
dbopcoerce.xhtml . . . 201
dbopcolumn.xhtml . . . 201
dbopcompactfraction.xhtml . . . 201
dbopcomplexeigenvectors.xhtml . . . 201
dbopcomplexelementary.xhtml . . . 202
dbopcomplexintegrate.xhtml . . . 202
dbopcomplexlimit.xhtml . . . 202
dbopcomplexsolve.xhtml . . . 202
dbopcontent.xhtml . . . 203
dbopcontinuedfraction.xhtml . . . 203
dbopconvergents.xhtml . . . 203
dbopconvert.xhtml . . . 203
dbopcopy.xhtml . . . 204
dbopcos.xhtml . . . 204
dbopcosh.xhtml . . . 204
dbopcot.xhtml . . . 204
dbopcoth.xhtml . . . 205
dbopcount.xhtml . . . 205
dbopcountableq.xhtml . . . 205
dbopcreate3space.xhtml . . . 205
dbopcsc.xhtml . . . 206
dbopcsch.xhtml . . . 206
dbopcurve.xhtml . . . 206
dbopcycleragits.xhtml . . . 206
dbopcyclotomic.xhtml . . . 207
dbopd.xhtml . . . 207

dbopdecimal.xhtml . . . 207
dbopdefiningpolynomial.xhtml . . . 207
dbopdegree.xhtml . . . 208
dbopdenom.xhtml . . . 208
dbopdraw.xhtml . . . 208
dbopdeterminant.xhtml . . . 208
dbopdiagonalmatrix.xhtml . . . 209
dbopdigamma.xhtml . . . 209
dbopdigits.xhtml . . . 209
dbopdimension.xhtml . . . 209
dbopdivide.xhtml . . . 210
dbopdivisors.xhtml . . . 210
dbopei.xhtml . . . 210
dbopeigenmatrix.xhtml . . . 210
dbopeigenvalues.xhtml . . . 211
dbopeigenvector.xhtml . . . 211
dbopeigenvectors.xhtml . . . 211
dbopelt.xhtml . . . 211
dbopequal.xhtml . . . 212
dbopeulere.xhtml . . . 212
dbopeulerphi.xhtml . . . 212
dbopeval.xhtml . . . 212
dbopevenq.xhtml . . . 213
dbopexp.xhtml . . . 213
dbopexquo.xhtml . . . 213
dbopfactor.xhtml . . . 213
dbopfactorfraction.xhtml . . . 214
dbopfibonacci.xhtml . . . 214
dbopfiniteq.xhtml . . . 214
dbopfirstdenom.xhtml . . . 214
dbopfirstnumer.xhtml . . . 215
dbopfractragits.xhtml . . . 215
dbopfractionpart.xhtml . . . 215
dbopgamma.xhtml . . . 215
dbopgcd.xhtml . . . 216
dbophermiteh.xhtml . . . 216
dbophex.xhtml . . . 216
dbophorizconcat.xhtml . . . 216
dbophtrigs.xhtml . . . 217
dbophypergeometric0f1.xhtml . . . 217
dbopinteger.xhtml . . . 217
dbopintegrate.xhtml . . . 217
dbopinverse.xhtml . . . 218
dbopinvmod.xhtml . . . 218
dbopjacobi.xhtml . . . 218
dboplaguerrel.xhtml . . . 218

dboplaurent.xhtml . . . 219
dboplcm.xhtml . . . 219
dbopleadingcoefficient.xhtml . . . 219
dbopleadingmonomial.xhtml . . . 219
dboplegendre.xhtml . . . 220
dboplength.xhtml . . . 220
dboplimit.xhtml . . . 220
dboplog.xhtml . . . 220
dboploggamma.xhtml . . . 221
dbopmainvariable.xhtml . . . 221
dbopmakegraphimage.xhtml . . . 221
dbopmakeobject.xhtml . . . 221
dbopmakeviewport3d.xhtml . . . 222
dbopmap.xhtml . . . 222
dbopmapbang.xhtml . . . 222
dbopmatrix.xhtml . . . 222
dbopmax.xhtml . . . 223
dbopmemberq.xhtml . . . 223
dbopmin.xhtml . . . 223
dbopminimumdegree.xhtml . . . 223
dbopminus.xhtml . . . 224
dbopmoebiusmu.xhtml . . . 224
dbopmonicdivide.xhtml . . . 224
dbopmulmod.xhtml . . . 224
dbopncols.xhtml . . . 225
dbopnegativeq.xhtml . . . 225
dbopnew.xhtml . . . 225
dbopnextprime.xhtml . . . 225
dbopnorm.xhtml . . . 226
dbopnrows.xhtml . . . 226
dbopnthfractionalterm.xhtml . . . 226
dbopnthroot.xhtml . . . 226
dbopnumer.xhtml . . . 227
dbopnumeric.xhtml . . . 227
dbopoddq.xhtml . . . 227
dboponedimensionalarray.xhtml . . . 227
dbopoperator.xhtml . . . 228
dboporthonormalbasis.xhtml . . . 228
dbopoutputfixed.xhtml . . . 228
dbopoutputfloating.xhtml . . . 228
dbopoutputgeneral.xhtml . . . 229
dbopoutputspacing.xhtml . . . 229
dboppadicfraction.xhtml . . . 229
dbopnullity.xhtml . . . 229
dbopnullspace.xhtml . . . 230
dbopnumberoffractionalterms.xhtml . . . 230

dboppartialfraction.xhtml . . . 230
dboppartialquotients.xhtml . . . 230
dbopplus.xhtml . . . 231
dboppattern.xhtml . . . 231
dboppermanent.xhtml . . . 231
dboppi.xhtml . . . 231
dboppolygamma.xhtml . . . 232
dbopposition eq.xhtml . . . 232
dboppositiveremainder.xhtml . . . 232
dbopprefixragits.xhtml . . . 232
dbopprevprime.xhtml . . . 233
dbopprimefactor.xhtml . . . 233
dbopprimeq.xhtml . . . 233
dbopprimes.xhtml . . . 233
dboppuiseux.xhtml . . . 234
dbopqelt.xhtml . . . 234
dbopqseteltbang.xhtml . . . 234
dbopquatern.xhtml . . . 234
dbopradicaleigenvectors.xhtml . . . 235
dbopradicalsolve.xhtml . . . 235
dboprank.xhtml . . . 235
dbopratdenom.xhtml . . . 235
dboprealeigenvectors.xhtml . . . 236
dboprealelementary.xhtml . . . 236
dbopreduce.xhtml . . . 236
dbopreductum.xhtml . . . 236
dboprem.xhtml . . . 237
dbopquo.xhtml . . . 237
dbopresetvariableorder.xhtml . . . 237
dbopresultant.xhtml . . . 237
dboprootof.xhtml . . . 238
dboprootsimp.xhtml . . . 238
dboprootsof.xhtml . . . 238
dbopseries.xhtml . . . 238
dbopround.xhtml . . . 239
dboprow.xhtml . . . 239
dboprowechelon.xhtml . . . 239
dbopsetcolumnbang.xhtml . . . 239
dbopseteltbang.xhtml . . . 240
dbopsetrowbang.xhtml . . . 240
dbopsetelt.xhtml . . . 240
dbopsetsubmatrixbang.xhtml . . . 240
dbopsign.xhtml . . . 241
dbopsimplify.xhtml . . . 241
dbopseriessolve.xhtml . . . 241
dbopsin.xhtml . . . 241

dbopsingleintegerand.xhtml . . . 242
dbopsingleintegernot.xhtml . . . 242
dbopsingleintegeror.xhtml . . . 242
dbopsingleintegerxor.xhtml . . . 242
dbopsec.xhtml . . . 243
dbopsech.xhtml . . . 243
dbopsetvariableorder.xhtml . . . 243
dbopsinh.xhtml . . . 243
dbopsolve.xhtml . . . 244
dbopsqrt.xhtml . . . 244
dbopstar.xhtml . . . 244
dbopstarstar.xhtml . . . 244
dbopsubmatrix.xhtml . . . 245
dbopsubmod.xhtml . . . 245
dbopsurface.xhtml . . . 245
dbopsumofkthpowerdivisors.xhtml . . . 245
dboptan.xhtml . . . 246
dboptanh.xhtml . . . 246
dboptaylor.xhtml . . . 246
dboptimes.xhtml . . . 246
dboptotaldegree.xhtml . . . 247
dboptrace.xhtml . . . 247
dboptranspose.xhtml . . . 247
dboptrigs.xhtml . . . 247
dboptruncate.xhtml . . . 248
dbopvariables.xhtml . . . 248
dbopvectorise.xhtml . . . 248
dbopvectorspace.xhtml . . . 248
dbopwrite.xhtml . . . 249
dbopzeroof.xhtml . . . 249
dbopzerosof.xhtml . . . 249
dbopzeroq.xhtml . . . 249
dbopvertconcat.xhtml . . . 250
dbopwholepart.xhtml . . . 250
dbpolynomialinteger.xhtml . . . 250
dbpolynomialfractioninteger.xhtml . . . 250
dbopwholeragits.xhtml . . . 251
definiteintegral.xhtml . . . 251
determinantofhilbert.xhtml . . . 252
differentiate.xhtml . . . 254
dlmf.xhtml . . . 254
dlmfapproximations.xhtml . . . 256
dlmfasymptoticexpansions.xhtml . . . 265
dlmfbarnesgfunction.xhtml . . . 309
dlmfbetafunction.xhtml . . . 325
dlmfcontinuedfractions.xhtml . . . 352

dlmfdefinitions.xhtml . . . 358
dlmffunctionrelations.xhtml . . . 367
dlmfgraphics.xhtml . . . 383
dlmfinequalities.xhtml . . . 388
dlmfinfiniteproducts.xhtml . . . 401
dlmfintegrals.xhtml . . . 411
dlmfintegralrepresentations.xhtml . . . 427
dlmfmathematicalapplications.xhtml . . . 463
dlmfmethodsofcomputation.xhtml . . . 472
dlmfmultidimensionalintegral.xhtml . . . 474
dlmfnotation.xhtml . . . 500
dlmfphysicalapplications.xhtml . . . 507
dlmfpolygammafunctions.xhtml . . . 518
dlmfqgammaandbetafunctions.xhtml . . . 528
dlmfseriesexpansions.xhtml . . . 544
dlmfsums.xhtml . . . 560
dlmfsoftware.xhtml . . . 563
dlmfspecialvaluesandextrema.xhtml . . . 563
dlmftables.xhtml . . . 587
draw.xhtml . . . 633
draw2donevariable.xhtml . . . 635
draw2ddefinedcurve.xhtml . . . 636
draw2dpolynomialequation.xhtml . . . 638
draw3dtwovariable.xhtml . . . 639
draw3ddefinedtube.xhtml . . . 641
draw3ddefinedsurface.xhtml . . . 642
equdifferential.xhtml . . . 644
equdifferentiallinear.xhtml . . . 645
equdifferentialnonlinear.xhtml . . . 648
equdifferentialpowerseries.xhtml . . . 652
equationpage.xhtml . . . 654
equsystemlinear.xhtml . . . 655
examplesexposedpage.xhtml . . . 657
factored.xhtml . . . 657
foundationlibrarydocpage.xhtml . . . 658
funalgebraicfunctions.xhtml . . . 658
funelementaryfunctions.xhtml . . . 660
funoperatoralgebra.xhtml . . . 660
functionpage.xhtml . . . 665
funpatternmatching.xhtml . . . 666
funrationalfunctions.xhtml . . . 673
funsimplification.xhtml . . . 674
glossarypage.xhtml . . . 677
graphexamples.xhtml . . . 708
graphexamplesassorted.xhtml . . . 709
graphexamplesimplicit.xhtml . . . 710

graphexampleslistofpoints.xhtml . . . 711
graphexamplesonevariable.xhtml . . . 713
graphexamplesparametric.xhtml . . . 714
graphexamplespolar.xhtml . . . 715
graphexamplesthreed.xhtml . . . 716
graphicspage.xhtml . . . 718
graphviewports.xhtml . . . 718
graph2d.xhtml . . . 720
graph2dimplicit.xhtml . . . 720
graph2dlistsofpoints.xhtml . . . 721
graph2donevariable.xhtml . . . 723
graph2dparametric.xhtml . . . 725
graph2dpolar.xhtml . . . 726
graph3d.xhtml . . . 727
graph3dobjects.xhtml . . . 728
graph3dparametric.xhtml . . . 731
graph3dsurfaces.xhtml . . . 733
graph3dtubeplots.xhtml . . . 734
graph3dtwovariables.xhtml . . . 736
htxtoppage.xhtml . . . 737
indefiniteintegral.xhtml . . . 737
introtofloat.xhtml . . . 738
jenks.xhtml . . . 739
laurentseries.xhtml . . . 741
linalgpage.xhtml . . . 742
linconversion.xhtml . . . 744
lincreate.xhtml . . . 747
lineigen.xhtml . . . 751
linhilbert.xhtml . . . 754
linintro.xhtml . . . 756
linoperations.xhtml . . . 758
linpermaent.xhtml . . . 761
linsquarematrices.xhtml . . . 762
linvectors.xhtml . . . 764
lin1darrays.xhtml . . . 767
lin2darrays.xhtml . . . 769
man0page.xhtml . . . 774
menualgebraadjointmatrix.xhtml . . . 776
menualgebraapplytolist.xhtml . . . 776
menualgebracharacteristicpolynomial.xhtml . . . 776
menualgebradeterminant.xhtml . . . 776
menualgebraeigenvalues.xhtml . . . 777
menualgebraeigenvectors.xhtml . . . 777
menualgebraentermatrix.xhtml . . . 777
menualgebrainvertmatrix.xhtml . . . 777
menualgebrageneratematrix.xhtml . . . 778

menualgebramakelist.xhtml . . . 778
menualgebramaptolist.xhtml . . . 778
menualgebramaptomatrix.xhtml . . . 778
menualgebrareducelist.xhtml . . . 779
menualgebratransposematrix.xhtml . . . 779
menuaxiomaddtopath.xhtml . . . 779
menuaxiomclearmemory.xhtml . . . 780
menuaxiomdeletefunction.xhtml . . . 780
menuaxiomdeletevariable.xhtml . . . 780
menuaxiominterrupt.xhtml . . . 780
menuaxiomrestart.xhtml . . . 781
menuaxiomshowdefinition.xhtml . . . 781
menuaxiomdisplay.xhtml . . . 781
menuaxiomset.xhtml . . . 781
menuaxiomshowfunctions.xhtml . . . 782
menuaxiomshowvariables.xhtml . . . 782
menuaxiomtoggletimedisplay.xhtml . . . 782
menucalculuscalculussum.xhtml . . . 782
menucalculuscalculusproduct.xhtml . . . 783
menucalculuschangevariable.xhtml . . . 783
menucalculuscontinuedfractions.xhtml . . . 783
menucalculusdifferentiate.xhtml . . . 783
menucalculusdividepolynomials.xhtml . . . 784
menucalculusfindlimit.xhtml . . . 784
menucalculusgetseries.xhtml . . . 784
menucalculusgreatestcommondivisor.xhtml . . . 784
menucalculusleastcommonmultiple.xhtml . . . 785
menucalculusintegrate.xhtml . . . 785
menucalculusinverselaplacetransform.xhtml . . . 785
menucalculuslaplacetransform.xhtml . . . 785
menucalculuslevel3.xhtml . . . 786
menucalculuslevel3a.xhtml . . . 786
menucalculuslevel3b.xhtml . . . 786
menucalculuslevel3c.xhtml . . . 786
menucalculuspadeapproximation.xhtml . . . 787
menucalculuspartialfractions.xhtml . . . 787
menucalculusrischintegrate.xhtml . . . 787
menueditcopy.xhtml . . . 787
menueditcopyasimage.xhtml . . . 788
menueditcopytex.xhtml . . . 788
menueditcopytext.xhtml . . . 788
menueditcut.xhtml . . . 788
menueditpaste.xhtml . . . 789
menueditdeleteselection.xhtml . . . 789
menueditselectiontoimage.xhtml . . . 789
menueditselectiontoinput.xhtml . . . 789

menuequationsrealrootsofpolynmial.xhtml . . . 790
menuequationsatvalue.xhtml . . . 790
menuequationsboundaryvalueproblem.xhtml . . . 790
menuequationsinitialvalueproblem1.xhtml . . . 790
menuequationsinitialvalueproblem2.xhtml . . . 791
menuequationssolvealgebraicsystem.xhtml . . . 791
menuequationseliminatevariable.xhtml . . . 791
menuequationssolvelinearsystem.xhtml . . . 791
menuequationssolveode.xhtml . . . 792
menuequationssolveodewithlaplace.xhtml . . . 792
menuequationsrootsofpolynomial.xhtml . . . 792
menuequationssolve.xhtml . . . 792
menuequationssolvenumerically.xhtml . . . 793
menufileexit.xhtml . . . 793
menufileinputfile.xhtml . . . 793
menufileloadlibrary.xhtml . . . 793
menufileopen.xhtml . . . 794
menufileprint.xhtml . . . 794
menufileread.xhtml . . . 794
menufilesave.xhtml . . . 794
menufilesaveas.xhtml . . . 795
menufiletogglespool.xhtml . . . 795
menunumericsetprecision.xhtml . . . 795
menunumerictobigfloat.xhtml . . . 795
menunumerictofloat.xhtml . . . 796
menunumerictogglenumericoutput.xhtml . . . 796
menusimplifyaddalgebraicequality.xhtml . . . 796
menusimplifycomplexsimplification.xhtml . . . 796
menusimplifycontractlogarithms.xhtml . . . 797
menusimplifyevaluatenounform.xhtml . . . 797
menusimplifyexpandexpression.xhtml . . . 797
menusimplifyexpandlogarithms.xhtml . . . 797
menusimplifyfactorialsandgamma.xhtml . . . 798
menusimplifyfactorcomplex.xhtml . . . 798
menusimplifyfactorexpression.xhtml . . . 798
menusimplifymoduluscomputation.xhtml . . . 798
menusimplifysimplifyexpression.xhtml . . . 799
menusimplifysubtitute.xhtml . . . 799
menusimplifysimplifyradicals.xhtml . . . 799
menusimplifytogglealgebraicflag.xhtml . . . 799
menusimplifytrigsimplification.xhtml . . . 800
numbasicfunctions.xhtml . . . 800
numberspage.xhtml . . . 805
numcardinalnumbers.xhtml . . . 807
numcomplexnumbers.xhtml . . . 811
numcontinuedfractions.xhtml . . . 814

numexamples.xhtml . . . 820
numfactorization.xhtml . . . 821
numfinitefields.xhtml . . . 823
numfloat.xhtml . . . 824
numfractions.xhtml . . . 826
numfunctions.xhtml . . . 827
numgeneralinfo.xhtml . . . 832
numintegerfractions.xhtml . . . 833
numintegers.xhtml . . . 833
nummachinefloats.xhtml . . . 835
nummachinesizedintegers.xhtml . . . 838
numnumbertheoreticfunctions.xhtml . . . 840
numnumericfunctions.xhtml . . . 842
numoctonions.xhtml . . . 852
numotherbases.xhtml . . . 855
numpartialfractions.xhtml . . . 858
numproblems.xhtml . . . 861
numquaternions.xhtml . . . 864
numquotientfields.xhtml . . . 866
numrationalnumbers.xhtml . . . 869
numrepeatingbinaryexpansions.xhtml . . . 871
numrepeatingdecimals.xhtml . . . 872
numrepeatinghexexpansions.xhtml . . . 874
numromannumerals.xhtml . . . 876
ocwmit18085.xhtml . . . 878
ocwmit18085lecture1.xhtml . . . 879
ocwmit18085lecture2.xhtml . . . 886
operations.xhtml . . . 887
outputfunctions.xhtml . . . 887
pagelist.xhtml . . . 889
pagematrix.xhtml . . . 889
pageonedimensionalarray.xhtml . . . 889
pageset.xhtml . . . 889
pagetable.xhtml . . . 890
pagepermanent.xhtml . . . 890
pagesquarematrix.xhtml . . . 890
pagetwodimensionalarray.xhtml . . . 890
pagevector.xhtml . . . 895
polybasicfunctions.xhtml . . . 895
polyfactorization.xhtml . . . 898
polyfactorization1.xhtml . . . 899
polyfactorization2.xhtml . . . 900
polyfactorization3.xhtml . . . 901
polyfactorization4.xhtml . . . 903
polygcdandfriends.xhtml . . . 904
polynomialpage.xhtml . . . 905

polyroots.xhtml . . . 906
polyroots1.xhtml . . . 907
polyroots2.xhtml . . . 909
polyroots3.xhtml . . . 911
polyroots4.xhtml . . . 913
polyspecifictypes.xhtml . . . 915
polyspecifictypes1.xhtml . . . 916
polyspecifictypes2.xhtml . . . 926
polyspecifictypes3.xhtml . . . 933
polyspecifictypes4.xhtml . . . 936
polysubstitutions.xhtml . . . 938
puiseuxseries.xhtml . . . 940
reallimit.xhtml . . . 941
refsearchpage.xhtml . . . 942
releasenotes.xhtml . . . 943
rootpage.xhtml . . . 944
series.xhtml . . . 946
seriesexpand.xhtml . . . 947
solve.xhtml . . . 948
solvelinearequations.xhtml . . . 949
solvelinearmatrix.xhtml . . . 951
solvesinglepolynomial.xhtml . . . 956
solvesystempolynomials.xhtml . . . 957
summation.xhtml . . . 957
systemvariables.xhtml . . . 957
taylorseries.xhtml . . . 958
topexamplepage.xhtml . . . 959
topicspage.xhtml . . . 960
topreferencepage.xhtml . . . 961
topsettingspage.xhtml . . . 962
tutorial.xhtml . . . 962
uglangpage.xhtml . . . 963
ugsyscmdpage.xhtml . . . 963
usersguidepage.xhtml . . . 963
rcm3720.input . . . 963
signatures.txt . . . 964
strang.input . . . 965
bitmaps/axiom1.bitmap . . . 966
License . . . 971

Bibliography **973**

Volume 12: Axiom Crystal

Axiom Crystal Design **1**
1.1 Book presentation 1
1.1.1 Book spines 1
1.1.2 Linking information 1

Experiments **3**
1.2 Hide/Show a div element 3
1.3 Hide/Show a nested div element 3
1.4 Hide/Show a ring of elements 4

Other work **7**
1.5 Understanding the Dynamics of Complex Lisp Programs [**?**] 7

Bibliography **9**

Volume 13: Proving Axiom Correct

1 Why this effort will not succeed **5**
1.1 General problems with formal verification 11

2 Progress Will Occur **13**

3 Here is a problem **15**
3.1 Proving the Algebra 15
3.1.1 Defining the Spad syntax 15
3.1.2 Defining the Spad semantics 15
3.1.3 Type Resolution 16
3.2 Proving the Logic 17
3.2.1 Typing and Subtyping 18
3.2.2 Defining the Algebra specifications 18
3.2.3 Termination 19
3.3 Proving the Lisp 19
3.4 Proving the Compiler 19
3.5 Proving to the metal 19
3.6 Setting up the problem 20
3.7 Axiom NNI GCD 21
3.8 Mathematics 23
3.9 Approaches 24

4 Theory **27**
4.0.1 Hoare's axioms and gcd proof 28
4.1 The Division Algorithm 28
4.2 Floating Point Proofs 30

5 GCD in Miranda by Broda, et al. **31**

6 GCD in COQ **35**

7 GCD in Nuprl by Anne Trostle **37**

8 Software Details **39**
8.1 Installed Software 39

9 Temporal Logic of Actions (TLA) **41**
9.1 The algorithm 41
9.1.1 Creating a new TLA+ module 42
9.1.2 Definitions 42
9.1.3 Constants and variables 42
9.1.4 The specification 42
9.1.5 Summary 43
9.2 A simple proof 44

9.2.1 The invariant . . . 44
9.2.2 Checking proofs . . . 44
9.2.3 Using facts and definitions . . . 44
9.3 Divisibility Definition . . . 45

10 COQ proof of GCD **47**
10.1 Basics of the Calculus of Constructions . . . 47
10.1.1 Terms . . . 47
10.1.2 Judgements . . . 47
10.1.3 Inference Rules . . . 48
10.1.4 Defining Logical Operators . . . 48
10.1.5 Defining Types . . . 49
10.2 Why does COQ have Prop? . . . 49
10.3 Source code of COQ GCD Proof . . . 50

11 LEAN proof of GCD **59**

12 Formal Pre- and Post-conditions **67**

13 Types and Signatures **69**

14 COQ nat vs Axiom NNI **73**
14.0.1 Library Coq.Init.Nat . . . 73

15 Binary Power in COQ by Casteran and Sozeau **79**
15.1 On Monoids . . . 80
15.1.1 Classes and Instances . . . 81
15.1.2 A generic definition of `power` . . . 82
15.1.3 Instance Resolution . . . 82
15.2 More Monoids . . . 83
15.2.1 Matrices over some ring . . . 83
15.3 Reasoning within a Type Class . . . 84
15.3.1 The Equivalence Proof . . . 85
15.3.2 Some Useful Lemmas About `power` . . . 85
15.3.3 Final Steps . . . 86
15.3.4 Discharging the Context . . . 87
15.3.5 Subclasses . . . 87

16 Proof Tower Layer: C11 using CH_2O **89**

17 Other Ideas to Explore **91**
17.1 Aczel [**?**] . . . 91
17.2 Chlipala [**?**] . . . 91
17.3 Dijkstra [**?**] . . . 91
17.4 Feferman [**?**] . . . 92
17.4.1 Homann [**?**] . . . 93
17.5 Igarashi et al. [Igar75] . . . 93

17.6 Kamareddine [Kama15] . . . 95
17.7 Mahboubi [?] . . . 95
17.8 Medina-Bulo et al. [?] . . . 95
17.9 Pierce [?] . . . 96
17.10Santas [?] . . . 96
17.11Spitters [?] . . . 96
17.12Théry [?] . . . 96

A The Global Environment **97**

B Related work **99**
B.1 Overview of related work . . . 99
B.1.1 Adams [?] . . . 99
B.1.2 Ballarin [?] . . . 99
B.1.3 Basu, Pollack,and Roy [?] . . . 99
B.1.4 Cloostermans [?] . . . 99
B.1.5 Berger and Schwichtenberg [?] . . . 103
B.1.6 Cardelli [?] . . . 104
B.1.7 Char [?] . . . 105
B.1.8 Chen [?] . . . 105
B.1.9 Chen [?] . . . 105
B.1.10 Clarke [?] . . . 105
B.1.11 Crocker [?] . . . 106
B.1.12 Davenport [?] . . . 108
B.1.13 Davenport [?] . . . 108
B.1.14 Davenport [?] . . . 108
B.1.15 Davenport [?] . . . 108
B.1.16 Davis [?] . . . 109
B.1.17 Dominus [?] . . . 109
B.1.18 Filliatre [?] . . . 109
B.1.19 Frege [?] . . . 110
B.1.20 Gianni and Trager [?] . . . 110
B.1.21 Galligo, Pottier and Traverso [?] . . . 110
B.1.22 Geddes, Gonnet, and Smedley [?] . . . 111
B.1.23 Gurevich [?] . . . 111
B.1.24 Harrison [?, p13] . . . 111
B.1.25 Hearn [?] . . . 112
B.1.26 Hoare [?] . . . 112
B.1.27 Hoare [?] . . . 112
B.1.28 Jenks [?] . . . 117
B.1.29 Jenks [?] . . . 117
B.1.30 Kaltofen [?] . . . 117
B.1.31 Kifer [?] . . . 117
B.1.32 lion137 [?] . . . 117
B.1.33 Manna and Waldinger [?] . . . 118
B.1.34 McAllester, D. and Arkondas, K., [?] . . . 120

B.1.35 Meshveliani [?] . . . 121
B.1.36 Myreen [?] . . . 121
B.1.37 Neuper [?] . . . 121
B.1.38 Nordström, Petersson, and Smith [?] . . . 121
B.1.39 O'Donnell [?] . . . 122
B.1.40 Paulson [?] . . . 123
B.1.41 Sanuki, Inaba, and Sasaki [?] . . . 123
B.1.42 Scott and Strachey [?] . . . 123
B.1.43 Smolka [?] . . . 124
B.1.44 Strub, Pierre Yves . . . 124
B.1.45 Sutor [?] . . . 126
B.1.46 Tsuji [?] . . . 126
B.1.47 Wang [?] . . . 126
B.1.48 Wijngaarden [?, Section 6, p95] . . . 127

A Untyped Lambda in Common Lisp **129**
A.0.49 LeanProver . . . 130

Bibliography **133**

Index **175**

Bibliography: Axiom Bibliography

1 The Axiom Bibliography **1**
1.1 Axiom Literate Sources . . . 1
1.2 Algebra Documentation References . . . 12
1.2.1 A . . . 12
1.2.2 B . . . 13
1.2.3 C . . . 21
1.2.4 D . . . 28
1.2.5 E . . . 29
1.2.6 F . . . 31
1.2.7 G . . . 35
1.2.8 H . . . 39
1.2.9 I . . . 44
1.2.10 J . . . 44
1.2.11 K . . . 46
1.2.12 L . . . 49
1.2.13 M . . . 54
1.2.14 N . . . 58
1.2.15 O . . . 58
1.2.16 P . . . 59
1.2.17 Q . . . 63
1.2.18 R . . . 64
1.2.19 S . . . 68
1.2.20 T . . . 74
1.2.21 U . . . 77
1.2.22 V . . . 77
1.2.23 W . . . 79
1.2.24 X . . . 85
1.2.25 Y . . . 85
1.2.26 Z . . . 85
1.3 Linear Algebra . . . 85
1.4 Algebraic Algorithms . . . 98
1.5 Sparse Linear Systems . . . 111
1.6 Matrix Determinants . . . 111
1.7 Open Problems . . . 112
1.8 Parallel Evaluation . . . 113
1.9 Hybrid Symbolic/Numeric . . . 114
1.10 Software Systems . . . 121
1.11 The Seven Dwarfs . . . 125
1.12 Solving Systems of Equations . . . 125
1.13 Numerical Algorithms . . . 127
1.14 Special Functions . . . 172
1.15 Exponential Integral $E_1(x)$ . . . 177
1.16 Polynomial GCD . . . 179

1.17 Category Theory . . . 182
1.18 Proving Axiom Correct – The Project . . . 184
1.19 Month51 . . . 238
1.19.1 D . . . 238
1.20 Coercion Survey – Fall 2018 . . . 239
1.20.1 A . . . 239
1.20.2 B . . . 256
1.20.3 C . . . 287
1.20.4 D . . . 318
1.20.5 E . . . 334
1.20.6 F . . . 338
1.20.7 G . . . 346
1.20.8 H . . . 366
1.20.9 I . . . 390
1.20.10 J . . . 392
1.20.11 K . . . 397
1.20.12 L . . . 411
1.20.13 M . . . 422
1.20.14 N . . . 440
1.20.15 O . . . 446
1.20.16 P . . . 451
1.20.17 Q . . . 461
1.20.18 R . . . 462
1.20.19 S . . . 474
1.20.20 T . . . 494
1.20.21 U . . . 507
1.20.22 V . . . 507
1.20.23 W . . . 508
1.20.24 X . . . 519
1.20.25 Y . . . 520
1.20.26 Z . . . 521
1.21 Proving Axiom Correct – Spring 2018 . . . 523
1.21.1 A . . . 523
1.21.2 B . . . 534
1.21.3 C . . . 544
1.21.4 D . . . 555
1.21.5 E . . . 565
1.21.6 F . . . 567
1.21.7 G . . . 579
1.21.8 H . . . 587
1.21.9 I . . . 592
1.21.10 J . . . 592
1.21.11 K . . . 595
1.21.12 L . . . 603
1.21.13 M . . . 608
1.21.14 N . . . 622

1.21.15 O . . . 623
1.21.16 P . . . 626
1.21.17 Q . . . 636
1.21.18 R . . . 636
1.21.19 S . . . 639
1.21.20 T . . . 654
1.21.21 U . . . 657
1.21.22 V . . . 657
1.21.23 W . . . 658
1.21.24 X . . . 664
1.21.25 Y . . . 666
1.21.26 Z . . . 666
1.22 Proving Axiom Sane – Coercion in CAS-Proof Systesms . . . 669
1.23 Proving Axiom Correct – CAS-Proof System Survey . . . 670
1.23.1 A . . . 670
1.23.2 B . . . 680
1.23.3 C . . . 708
1.23.4 D . . . 723
1.23.5 F . . . 732
1.23.6 G . . . 738
1.23.7 H . . . 746
1.23.8 J . . . 755
1.23.9 K . . . 757
1.23.10 L . . . 766
1.23.11 M . . . 770
1.23.12 N . . . 785
1.23.13 O . . . 788
1.23.14 P . . . 789
1.23.15 R . . . 802
1.23.16 S . . . 804
1.23.17 T . . . 809
1.23.18 W . . . 812
1.23.19 Y . . . 817
1.24 Interval Arithmetic . . . 818
1.25 Numerics . . . 820
1.26 Advanced Documentation . . . 823
1.27 Differential Equations . . . 825
1.28 Expression Simplification . . . 834
1.29 Integration . . . 837
1.30 Partial Fraction Decomposition . . . 882
1.31 Ore Rings . . . 883
1.32 Number Theory . . . 884
1.33 Sparse Polynomial Interpolation . . . 887
1.34 Divisions and Algebraic Complexity . . . 889
1.35 Polynomial Factorization . . . 892
1.36 Branch Cuts . . . 904

1.37 Square-free Decomposition . . . 912
1.38 Symbolic Summation . . . 915
1.39 Differential Forms . . . 930
1.40 Cylindrical Algebraic Decomposition . . . 934
1.40.1 A . . . 934
1.40.2 B . . . 938
1.40.3 C . . . 944
1.40.4 D . . . 951
1.40.5 E . . . 952
1.40.6 F . . . 956
1.40.7 G . . . 956
1.40.8 H . . . 958
1.40.9 J . . . 964
1.40.10 K . . . 964
1.40.11 L . . . 965
1.40.12 M . . . 965
1.40.13 P . . . 968
1.40.14 R . . . 969
1.40.15 S . . . 973
1.40.16 T . . . 974
1.40.17 W . . . 974
1.40.18 Z . . . 978
1.41 Comparison of Computer Algebra System . . . 979
1.42 Finite Fields . . . 981
1.43 To Be Classified . . . 991
1.44 Axiom Citations in the Literature . . . 1043
1.44.1 A . . . 1043
1.44.2 B . . . 1057
1.44.3 C . . . 1088
1.44.4 D . . . 1106
1.44.5 E . . . 1151
1.44.6 F . . . 1153
1.44.7 G . . . 1171
1.44.8 H . . . 1197
1.44.9 I . . . 1212
1.44.10 J . . . 1213
1.44.11 K . . . 1237
1.44.12 L . . . 1257
1.44.13 M . . . 1283
1.44.14 N . . . 1298
1.44.15 O . . . 1303
1.44.16 P . . . 1306
1.44.17 Q . . . 1313
1.44.18 R . . . 1313
1.44.19 S . . . 1319
1.44.20 T . . . 1358

1.44.21 U 1360
1.44.22 V 1360
1.44.23 W 1365
1.44.24 X 1393
1.44.25 Y 1393
1.44.26 Z 1394
1.45 Axiom Citations of External Sources 1398
1.45.1 A 1398
1.45.2 B 1406
1.45.3 C 1428
1.45.4 D 1440
1.45.5 E 1452
1.45.6 F 1455
1.45.7 G 1460
1.45.8 H 1474
1.45.9 I 1484
1.45.10 J 1485
1.45.11 K 1487
1.45.12 L 1499
1.45.13 M 1510
1.45.14 N 1521
1.45.15 O 1524
1.45.16 P 1526
1.45.17 Q 1537
1.45.18 R 1537
1.45.19 S 1547
1.45.20 T 1558
1.45.21 U 1561
1.45.22 V 1562
1.45.23 W 1564
1.45.24 X 1571
1.45.25 Y 1571
1.45.26 Z 1571

2 Beebe Bibliography **1579**

Index **1601**