

# Index

- |, Alternatives, 97
- &&, And, 50
- @@, Apply, 120
- @@@, Apply at level one, 121
- \_, Blank, 86
- \_\_\_, BlankNullSequence, III
- \_\_, BlankSequence, 86
- ;, CompoundExpression, 21
- /;, Condition, 92, 211
- ==, Equal, 170, 255
- @ (function application), 22
- // (function application), 22
- <<, Get, 555
- ?, Information, 25–26
- /@, Map, 118
- ||, Or, 51
- .., Repeated, 98, 412, 548–549
- ..., RepeatedNull, 98
- /. , ReplaceAll, 102
- // ., ReplaceRepeated, 104
- ===, SameQ, 170
- =, Set, 42
- :=, SetDelayed, 43
- #, Slot, 154
- ##, SlotSequence, 377–378
- ~~, StringExpression, 325
- <>, StringJoin, 317
- ˘ (context mark), 558
- ˘ (number mark), 268
- Aborting calculations, 24
- AbsoluteOptions, 375
- AbsoluteTiming, 494
- Accumulate, 136
- Accuracy, 265, 276
- AccuracyGoal, 278
- Adelston, Larry, xvii
- Adjacency matrices, 130
- Adjacency structures, 163
- AdjacencyGraph, 64, 130
- Adler checksum, 347
- Alternative input syntax, 21–22
- Alternatives (|), 97
  - in string patterns, 329
- Amino acids
  - residues of, 6–7
  - visualization of, 402–409
- Anagrams, 322, 359, 361
- And (&&), 50
- Animate, 450
- Animations
  - Animate, 450, 553
  - displaying all steps, 553
  - random walk, 469, 552–553
  - sorting algorithms, 228–230
- Annuity, present value, 4
- Appearance, 475–476
- Append, 75
- Apply (@@), 120
- ArcTan, 417
- Area of triangles, 108, 421
- Arguments to functions, 217
- Array, 64

- ArrayDepth, 69
- ArrayPlot, 64
- ArrayRules, 284
- Arrays, 282
  - constant, `ConstantArray`, 65, 78
  - creating, 64–65
  - of random numbers, 260
  - operations on, 182
  - packed, 286
  - random sparse, 290
  - sparse, `SparseArray`, 32, 65, 282
- Ascii characters, 311–312
- Assignments, 40
  - compared with transformation rules, 102
  - delayed, 43
  - immediate, 42
  - to list components, 76, 153
- Assumptions, in simplification, 3
- Atoms, 30
  - testing for, `AtomQ`, 49
- Attributes, 53
  - clearing, `ClearAll`, 55
  - clearing, `ClearAttributes`, 55, 124, 546
  - finding functions with, 160
  - `Flat`, 53–54
  - `Listable`, 56, 123, 208
  - `OneIdentity`, 54
  - `Orderless`, 54
  - `Protected`, 54
  - setting for a function, 55
- Autocorrelation, 304
  - of white noise, 446
  
- Band, 285
- `BaseForm`, 258–259
- `Begin`, 559
- Bernoulli trials, 129
- `BernoulliGraphDistribution`, 129
- Bézier curves, 6–7
  - as edges in graphs, 376–380
  - with dynamic control points, 454–455
- `BezierCurve`, 378
- Bigrams, 81–82
- Binary shifts, computations with, 264
- Binding energy, of isotopes, 6
  
- `Binomial`, 127, 498
- Bit operators, 52–53, 171
- `BitOr`, 52
- `BitXor`, 52, 171
- Blanagrams, 359, 520
- `Blank` (`_`), 86
- `BlankNullSequence` (`___`), 86, 111
- `BlankSequence` (`_..`), 86
- Blas routines, 505
- `Block`, 147
- `BlockRandom`, 300–301
- Bond percolation, 12–14
- `Boole`, 65
- Boolean expressions
  - truth tables, 50, 188
  - visualizing with Venn diagrams, 468
- Boolean operators, 50
- Borges, Jorge L., 343
- `BoxWhiskerChart`, 427
- Brackets
  - cell, 16
  - for lists, 20
- Bubble sort, 112, 229
- `ByteCount`, 495
  
- C language
  - compilers, 527
  - number representation, 269
  - numerical limits of, 270, 272
  - pointers, 77
- Caenorhabditis elegans*, 177
- Caesar, Julius, 319, 384
- Calculations, interrupting or aborting, 24
- Calkins, Harry, xvii, 469
- Cards, creating deck of, 140
- Cartesian products, using transformation rules, 108
- Cases
  - basic examples, 87, 183–184
  - level specification of, 92
- Cell brackets, 16
- Center of mass, 295
- `CharacterRange`, 310
- Characters, in other languages, 313
- `Characters`, 317

- Checksums, 347
  - Adler, 348
- ChemicalData, 402–403
- Chemicals
  - positions of atoms, 403
  - radius of atoms, `VanDerWaalsRadius`, 403
  - visualization of, 402
- `ChiSquareDistribution`, 262
- Church, Alonzo, 115
- Ciphers
  - Caesar, 319, 324
  - permutation, 320, 324
- Circles, graphics primitive, `Circle`, 365
- `ClearAll`, 55, 567–568
- `ClearAttributes`, 55, 124
- Clearing
  - all symbols in `Global`` context, 374
  - attributes, `ClearAll`, 55
  - attributes, messages, or options, `ClearAll`, 546
  - values, 42
- Closed paths, example of transformation rules, 105
- `CloseKernels`, 516
- Collatz sequences, 101, 219
  - defined recursively, 243
  - package for, 573
- Color functions, CPK model for atoms, 404
- Color wheel, 385
- `ColorData`, 411
- Column, 182
  - options for, 485–486
- Comments, 23
- `CompilationTarget`, 527
- `Compile`, 524
- Compiled functions, 524
  - making listable, 525
  - parallelization of, 525
  - run-time options of, 526
- `CompiledFunction`, 524
- `CompiledFunctionTools`, 526
- `CompilePrint`, 526
- Compiling, 523
  - autocompile, 509
  - to C, 527
- `Complement`, 79
- Complex numbers, 35, 212, 255
  - length of, `Abs`, 256
  - pattern matching with, 256
  - phase angle, `Arg`, 256
  - plotting in the plane, 257
  - visualization of, 256, 446
- Composite numbers, 53, 95
- Compound expressions, 21
- Compression, encoding used in, 246
- Computation
  - fixed-precision, 148, 274
  - symbolic vs. numeric, 505
  - threading, 518
- Computational complexity, of sort algorithms, 112, 228
- Computational geometry
  - convex hull, 105, 395
  - point in polygon, 419, 518
  - ray crossing algorithms, 420, 423
- Condition number of matrices, 307
- Conditional functions
  - `If`, 208
  - `Piecewise`, 212
  - `Switch`, 215
  - `Which`, 214
- Conditions, in patterns, `Condition (/;)`, 92, 211
- Connected components, of graphs, 13
- `ConnectedGraphQ`, 49
- `ConstantArray`, 65, 78
- Constants
  - attributes of, 258
  - mathematical, 257
- `ContentSize`, 488
- Contexts, 558
  - current, `$Context`, 558
  - exiting current, `End`, 559–560
  - nested, 562
  - of symbols, `Context`, 560
  - path for, `$ContextPath`, 561
  - private, 563, 569
  - starting new, `Begin`, 559
- `Control`, 459
- Control objects, 452
  - inputting text, `InputField`, 457
  - `LocatorPane`, 476–477
  - locators, 455
  - popup menus, 453
  - setter bars, 453

- Control objects (continued)
  - sliders, 472
  - two-dimensional slider, `Slider2D`, 453–454, 529
  - viewers, 460
  - wrappers for, 459
- `ControlActive`, 530
- `ControlType`, 453
- Convex hulls
  - `ConvexHull`, 395
  - in computing closed paths, 105
- Convex polygons, 420
- Coordinates, spherical, 541
- Correlation, 304
- Correlograms, 305
- Count, 68, 100
- Counting
  - coins, using transformation rules, 104
  - number of multiplies, `MultiplyCount`, 108
  - steps inside looping constructs, 201, 503
- CPK model, for coloring atoms, 404
- `CreatePalette`, 485
- `CycleGraph`, 176–177
- Cylinder, 367
  
- Darwin, Charles, 330
- Dashing, 371
- Data
  - adding headers to tabular, 79
  - autocorrelation of, 304
  - displaying tabular, `Grid`, 62–63
  - dynamic tables of, 457–458
  - dynamic visualization of, 481
  - filtering, 114
  - finding convex hull for, 395–396
  - fitting with linear model, 7, 113, 228
  - handling missing, 408–409
  - importing, 7, 282
  - industrial production, 483
  - linear regression trendlines, 440
  - mean, 97, 429
  - measuring extent of, 294
  - Nobel prizes, 490
  - nonnumeric values in, 183
  - scraping from web pages, 327, 342
  - standard deviation of, 429
  - stem plots of, 166
  - time series, 438
  - trends in, 436
  - visualizing, `ArrayPlot`, 63
  - visualizing autocorrelation of, 305
- Date conversion, 153
- `DateListPlot`, 481, 483
- Defaults for function arguments, 204
- `Defer`, 40
- Definitions
  - for functions, 41
  - multiple, 45
  - of variables, 41
  - recursive, 232
- Delayed assignments, `SetDelayed` (`:=`), 43
- Delayed rules, `RuleDelayed` (`:=>`), 103
- `Delete`, 72
- `DeleteCases`, 100
- `DeleteDuplicates`, 79
- Detecting edges in images, 8
- Diameter of pointsets, 130, 164
- Dice
  - rolling of, 264
  - visualization using transformation rules, 109
- `DictionaryLookup`, 162, 314, 349
  - dynamic lookups, 481
- Differential equations
  - precision of solutions, 252
  - visualizing solutions of, 3
- Digit sums, 263
- Digital roots, 230
- `DigitCharacter`, 326
- Dimensions, 68
- `DisplayAllSteps`, 552
- `DistanceFunction`, 188
- `DistributeDefinitions`, 518
- `DistributionFitTest`, 298
- Divergence of vector field, 131–132
- DNA
  - bases used in random strings, 343
  - computing GC ratios, 351
  - displaying sequences of, 356
  - sequence analysis, 351
- Do
  - counting steps inside loop, 503–504
  - syntax of, 194

- Documentation Center, 26
- Dot product, `Dot`, 125–126
- Duchamp, Marcel, rotoreliefs, 469
- `Dynamic`, 472
- Dynamic expressions, 470
  - `Animate`, 450
  - constraining movement of, 477
  - direct manipulation, `Locator`, 455
  - efficiency, 479
  - finding substrings with, 349
  - formatting of, 459
  - issues with updating, 474, 479
  - limiting evaluation while active, 531
  - locators, 11, 455
  - `Manipulate`, 450
  - modifying appearance, 476
  - mouse events used in, 487–488
  - `OpenerView`, 462
  - reducing computation within, 479
  - saving state, 476
  - scoping of, `DynamicModule`, 474
  - setting control type, `ControlType`, 453
  - `TabView`, 10, 460
  - update intervals, `UpdateInterval`, 474
  - viewers, 460
- Dynamic programming, 239
- `DynamicModule`, 474
  
- Edge detection, `EdgeDetect`, 8, 472
- `EdgeShapeFunction`, 377
- Eigenvectors, visualization of, 297–298
- Elements of lists, 59
- Elevation data, reconstructing surface from, 8
- `EmitSound`, 397
- Encoding
  - in compression algorithms, 246
  - text, 318
- `End`, 559–560
- `Entropy`, 265
- Epicycloids, 386, 469
- `Equal` (`==`), 170, 255
- Equality, testing for, `SameQ` vs. `Equal`, 170, 255
- Eratosthenes, sieving, 224, 503
- Error function, complementary, `Erfc`, 300
  
- Errors, syntax coloring of, 23
- Euler, Leonhard, 523
- Eulerian numbers, 242
- `Evaluate`, 39, 505
- `Evaluated`, 505
- Evaluation
  - deferring, `Defer`, 40
  - of input, 17
  - overriding held, 39–40
  - preventing with `HoldForm`, 39
- `EvaluationMonitor`, 201, 280
- `EventHandler`, 487
- `ExponentialMovingAverage`, 163
- Exponentiation, notation, 19
- Expressions, 29
  - atomic, 30
  - entering traditional, 18–19
  - head of, 30
  - internal form of, 33
  - mapping functions over, 118
  - normal, 33
  - number of elements in, 33
  - parts of, 35
  - selecting parts, 35, 37
  - structure of, 33
  - threading functions over, 122
  - visualizing with `TreeForm`, 36
  
- `FaceGrids`, 367
- Factorial, by iteration, 137
- Factoring
  - large integers, 515
  - numbers, 132
  - polynomials, 2
- Fibonacci numbers
  - computed iteratively, 205
  - computed using determinants, 290
  - definition, 95
  - matrix computation, 290
  - negative integer indices, 234
  - recursive implementation, 232
  - speeding up computation of, 234
  - using dynamic programming, 240
- File browsers, dynamic using `OpenerView`, 484

- Filtering data, 96, 100, 114, 126
- `FilterRules`, 432–433, 549
- `FinancialData`, 96, 437
- `FindFile`, 558
- `FindRoot`, 191
  - displaying intermediate values, 201, 205
  - options for, 279
- `FindShortestTour`, 491
- `First`, 72
- Fitting data, 7–8
  - `LinearModelFit`, 113, 228
- Fixed range tests, 301
- Fixed-precision computations, 148, 274
- `FixedPoint`, 134
- `Flat`, 53–54
- `Flatten`, 76, 141
- `Fold`, 136, 239
- `FoldList`, 136, 239
- Fonts, displaying lists of, 468
- `For`, syntax of, 195
- `FreeQ`, 68
- Frequency modulation (FM) synthesis, 402
- Frequency tests, 299
- Friendship network, 376
- `FromCharacterCode`, 312
- Front end, 24
- `FullForm`, 33
  - of strings, 311
- `Function`, 153, 156
- Functions
  - alternate syntax for, 21
  - applying, `Apply`, 120
  - argument checking, 217
  - compound, 143
  - conditional, 208
  - definitions for, 41
  - indexed, `MapIndexed`, 158
  - information about, 25–26
  - inheriting options, 166, 175
  - iterated, `Nest`, 132
  - making listable, 123
  - mapping of, 118
  - multiple definitions for, 45
  - nesting of, 137
  - options for built-in, 164
  - piecewise-defined, 4, 48, 212
  - predicate, 48, 126
  - pure, `Function`, 153, 156
  - setting attributes, 55
  - templates for, 565
  - threading, `Thread`, 122
- `GatherBy`, 426
- GC ratios, 329, 351
- `GenomeData`, 345
- `GenomeLookup`, 109
- Geometric transformations, 375
  - translations, 395
- `Get` (`<<`), 555
- Glosemeyer, Darren, xvii
- Golden ratio, as fixed point, 134
- Graphics
  - box representation, 392
  - cached values, 392
  - color wheels, 385
  - defining new objects, 12
  - directives, 366, 369
  - displaying, 365–366
  - efficient representation of, 386
  - lighting of three-dimensional, 404
  - lines in, `Line`, 369, 409
  - multi-objects, 386
  - numeric vs. symbolic values, 392
  - options, 366, 370
  - points in, 369
  - primitives, 365, 368
  - reflection of lights, `Specularity`, 404
  - reflection transforms, 375
  - representation with `GraphicsComplex`, 389
  - rotating, 133
  - space-filling plots, 402
  - structure of built-in, 374
  - text in, `Text`, 372
  - three-dimensional, 367
  - tick marks and labels, 371
  - translation of, 134
  - visualization of trends in data, 436
  - visualizing roots of functions, 430
- `Graphics`, 365

- Graphics3D, 367
- GraphicsComplex, 389
- Graphs
  - adjacency, 64, 130
  - adjacency structures, 163
  - bond percolation, 12–14
  - connected components, 13
  - counting edges incident to vertex,
    - VertexDegree, 178
  - deleting self-loops, 180
  - function for edges, 377
  - power grid as, 63
  - random, 127
  - regular, 176
  - representing networks, 376
  - testing for connected, ConnectedGraphQ, 49
- Greatest common divisor, 206, 230
- Grid, 62
  - displaying DNA sequences, 357
  - inheriting options from, 358
- Hamiltonian cycle, 13
- Hamming distance, 170, 187
  - efficiency issues, 514
- Hamming (regular) numbers, 163
- Hamming weight, 263
- Hash tables, 347
- Hendrix, Jimi, 400
- Hexagonal lattice, 395
- HoldAll, 433, 504
  - used to measure timing, 494
- HoldForm, 39
- Horner's method, for polynomial multiplication, 162
- Hyperlink, 181
- Hyperlinks
  - styles for, 485
  - syntax for, 484
- Hypocycloids, 381
  - animation of, 462
- HypothesisTestData, 299
- IdentityMatrix, 538
- If, 208
  - nested structures, 210
- Image processing
  - edge detection, 8, 472
  - effects, ImageEffect, 468
  - resizing, 209
  - segmentation, 11
- Immediate assignment, 42
- Importing
  - data, 7
  - images, 8
- Indexed functions, MapIndexed, 157
- Industrial production data, 483
- Inequalities, visualizing systems of, 466
- Infix notation, 22
- Information, about built-in functions, 25–26
- Information retrieval, 332
- Information theory, 265
- Initialization, 454–455
- Inner products, Inner, 125
- Input
  - alternative syntax for, 21
  - entering, 17
  - evaluation of, 17
- InputField, 457
- InputForm
  - of plots, 374
  - of strings, 311
- Insert, 75
- Integer lattice, 67
- IntegerDigits, 258
- Interactomes, 177
- Interleaving lists, Riffle, 142, 239
- Interrupting calculations, 24
- Intersection of lists, Intersection, 79
- Intervals, testing for membership,
  - IntervalMemberQ, 49
- InverseCDF, 301
- Isotopes, binding energies, 6
- Iteration
  - counting steps, 201
  - fixed point, FixedPoint, 134
  - functions of two arguments, Fold, 136
  - intermediate values, EvaluationMonitor, 201, 280
  - intermediate values, Reap and Sow, 281
  - of functions, 132
  - setting with built-in functions,
    - MaxIterations, 279
  - Sierpinski triangle, 137
  - with conditions, NestWhile, 135

- Johnson, Bob, *xvii*
- `Join`, 78
- Josephus problem, 172, 264
- Joyce, James, 331
- Julia, Gaston, 532
- Julia sets, 527
  
- Kelly, Michael, *xvii*
- Kernel, 24
- Klee, Paul, 365
- Kuzniarek, Andre, *xvii*
  
- Lag plots, 308
- Lags in time series, 304
- Languages
  - C, 269
  - Lisp, xi, 115
- `Last`, 72
- Lattices
  - hexagonal, 395
  - three-dimensional, 395
  - visualizing integer, 67
- `LaunchKernels`, 516
- Length of
  - expressions, `Length`, 33
  - lists, 68
- `LetterCharacter`, 326
- `LetterQ`, 311
- Lévy flights, 554
- Lighting, 404
- Linear congruential method, for generating
  - random numbers, 264, 301
- Linear systems of equations, solution of, 3
- `LinearModelFit`, 113, 228
- Lines
  - connecting 3D data with, 409
  - dashed, 371
  - in two-dimensional graphics, 369
- Lisp programming language, xi, 115
- Listability, 508
  - of compiled functions, 525
  - setting attribute, 56, 123, 208
- `Listable`, 123
- `ListPlay`, 398–399
- `ListQ`, 49
  
- Lists
  - complement of, 79
  - component assignment, 76, 150
  - constructing, 59
  - counting frequency of elements in, 68
  - creating nested, 61
  - deleting duplicates, 79
  - depth of, 69
  - displaying, 62
  - elements of, 59
  - extracting elements from, 70
  - flattening, 76
  - interleaving, `Riffle`, 142, 239
  - internal representation, 58
  - intersection of, 79
  - joining, 78
  - measuring, 68
  - merging, 244
  - partitioning, 74, 174
  - permutations of, 196
  - position of elements in, 67–68
  - removing elements, 72
  - replacing parts of, 76
  - reversing order of, 74
  - rotating, 74
  - sorting, 73, 111
  - syntax of, 20, 58
  - taking sublists, 70–71
  - testing for, `ListQ`, 49
  - testing for membership in, 68
  - transposing, 75
  - union of, 78
  - visual representation, `TreeForm`, 69
- Localization of
  - constants, `With`, 148, 176
  - names, `Module`, 146
  - values, `Block`, 147
- `Locator`, 455
- `LocatorAutoCreate`, 456
- `LocatorPane`, 477
- Logical operators, 50
  - visualizing expressions with, 466
- Logistic maps, loss of precision with, 274
- Lookahead/lookbehind constructs, 336



- Loops
  - Do, 194
  - Do vs. Table, 205
  - efficiency issues, 502
  - For, 195
  - NestWhile, 204
  - While, 199
- Lorentz factor, 1
- LowerCaseQ, 311
- Lucky numbers, 230
- Machine numbers, 266
- MachineIntegerQ, 270, 513
- MachineNumberQ, 513
- MachinePrecision, 266, 277
- Mandelbrot, Benoît, 446
- Mandelbrot set, 523
- Manipulate
  - basic syntax, 450
  - example with conditional functions, 210
  - initial values for parameters, 451
  - initializing, Initialization, 454–455
  - labels for parameters, 451
  - multiple parameters, 450–451
  - saving definitions, 465
  - size of content area, 488
- Map (/@), 118
  - at different levels, 121
- MapIndexed, 157
- Mapping over expressions, automatically,
  - Listable, 124
- MapThread, 122, 170, 175, 181, 185
- MatchQ, 86
- Mathematical constants, 257
- Mathematical expressions, linear syntax, 18
- Matrices
  - adding columns and rows, 81
  - adjacency, 130
  - column means, 188
  - displaying with MatrixForm, 62
  - identity, 538
  - ill-conditioned, 307
  - multiplication, 131
  - norm, 307
  - predicate for square, 93, 130
  - swapping rows and columns, 81, 150
  - testing for symmetry, SymmetricMatrixQ, 49, 283
  - tridiagonal, 290
  - upper triangular, 149, 218
  - Vandermonde, 131
  - visualizing, MatrixPlot, 63
- MatrixForm, 62
  - and sparse arrays, 284
- MatrixPlot, 63
- MaxIterations, 279
- Mean of data, 97
- Median, 187, 219
- MemberQ, 68, 161
- MemoryInUse, 495–496
- Merge sort, 113, 244
- Mersenne prime numbers, 126, 132
  - computing in parallel, 517
- Mesh, 415, 434
- MeshFunctions, 434
- Messages, 167
  - creating error, 546
  - for built-in functions, 167
  - framework for, 169
  - issuing, Message, 169
  - multiple, 169
  - usage, 546, 565, 568, 571
- MIDI instruments, 400
- Missing, 408
- Modular design, 183
- Module, 146
  - compared to With, 149–150
- Most, 73
- MouseClicked, 487–488
- Moving averages, exponential, 163
- Multi-objects, 386
- Multi-threaded computation, 518
- Multiplication, syntax for, 18
- Musical scales
  - pentatonic, 448
  - random walk across, 445
- Named patterns, 99
- Names, 161, 556
- Natural language processing
  - n*-grams, 81

- Natural language processing (continued)
  - stop words, 342–343
  - word length in corpora, 329
  - word stemming, 336
- Nearest, 188
- Needs, 555
- Nest, 132
- Nested function call, 137
- Nested functions, pure, 158
- NestList, 132, 239
- NestWhile, 135, 204
- Networks
  - friendship, 376
  - protein-protein interaction, 177
  - represented as graphs, 376
- Newton's method
  - accelerating for slow convergence, 307
  - controlling precision of, 291
  - derivative undefined, 293
  - for root finding, 192
  - numerical derivatives, 293
  - tolerance for, 199
- NIntegrate, 278
- Nobel prizes, 491
- Norm
  - of matrices, 307
  - used to compute distance in Euclidean space, 162
- Normal, 284
- Normal expressions, 33
- NormalDistribution, 261
- Normalize, 489
- Notebooks, working with, 15
- NP-complete problems, 415
- NSolve, 430
- Number mark (```), 268
- NumberQ, 49, 258
- Numbers, 251
  - accuracy of, Accuracy, 265
  - approximate, 266
  - bases of, 258
  - complex, Complex, 35, 212, 255
  - composite, 53, 95
  - computation with mixed types, 275
  - converting between bases, 263
  - display of approximate, 267
  - Eulerian, 242
  - exact vs. approximate, 269
  - extracting digits of, 258
  - factoring, 131
  - Fibonacci, 95, 205, 232
  - floating-point, Real, 255
  - Hamming (regular), 163
  - high precision vs. machine precision, 271
  - IEEE floating-point, 266
  - internal representation, FullForm, 254
  - lucky, 230
  - machine, 266
  - Mathematica compared to C, 269
  - mathematical constants, 257
  - Mersenne, 126
  - Mersenne prime, 132, 517
  - natural, 53
  - perfect, 11, 152, 523
  - polar representation, 263
  - precision of, 265
  - random, RandomReal, 260
  - rational, Rational, 254
  - rep units, 162
  - scale of approximate, 267
  - size limits, 271
  - test for composite, 53
  - testing for, NumericQ, 48
  - testing for explicit, NumberQ, 258
  - triangular, 514
  - type of, Head, 254
- NumberString, 326
- NumericQ, 48
- OneIdentity, 54
- OpenerView, 462
  - for file browsers, 485
- Operators
  - bit, 52
  - infix notation for, 24
  - logical, 50
  - postfix notation for, 22
  - prefix notation for, 21
  - relational, 50
- Options, 164
  - argument structure, OptionsPattern, 165
  - defaults, 204

- extracting values of, `OptionValue`, 165
- filtering, `FilterRules`, 432–433, 549
- finding functions with, 160
- for built-in functions, 165
- for graphics, 367, 370
- for three-dimensional graphics, 415
- for two-dimensional graphics, 370
- framework for, 164
- inheriting from built-in functions, 166, 175
- multiple instances of, 373
- obtaining for graphics expressions, 375
- use of `Automatic` in, 414
- `OptionsPattern`, 165, 433
- `OptionValue`, 165
- `Or (| |)`, 51
- `OrderedQ`, 315
- Outer products, `Outer`, 125, 141
- Output, referring to previous, 17
- `OutputForm`, of strings, 87, 310
  
- $\mathcal{P} = NP$ , 415
- P-values, for statistical tests, 298
- Packages, 558
  - beginning, `BeginPackage`, 564
  - built-in, 555
  - developing, 563
  - ending, `EndPackage`, 564
  - getting names in, 556
  - installing, 567
  - loading, 555, 562
  - location of, 557
  - template for, 563
- Packed arrays, 286
  - converting expressions to, `ToPackedArray`, 512
  - functions that autopack, 512
  - size of, 287
  - testing for, `PackedArrayQ`, 287
  - turning on messages associated with, 512
  - unpacking, 500
- Palettes
  - creation of, `CreatePalette`, 181–182, 485
  - customizing styles for, 182
- Palindromes, 324, 332
- Parallel computation
  - basic examples, 515
  - closing kernels, `CloseKernels`, 516
  - computations that do not parallelize, 518
  - distributing definitions, 518
  - graphical user interface for, 517
  - launching kernels, `LaunchKernels`, 516
  - loading packages on subkernels, 522
  - with compiled functions, 526
  - `$ProcessorCount`, 516
  - `ParallelEvaluate`, 518
  - `Parallelize`, 517
  - `ParallelMap`, 516
  - `ParallelNeeds`, 522
  - `ParallelTable`, 528
  - `ParametricPlot`, 383
  - `Part`, 35, 70
    - shorthand notation, `[ [... ] ]`, 70
  - `Partition`, 74, 143
  - Partitioning
    - lists, 74, 174
    - lists of digits, 110
    - lists of vertices, 422
    - strings, 345
  - Parts of expressions, `Part`, 35, 70
  - Pascoletti Adriano, xvii
  - Password generator, 345
  - `PathPlot`, 106
  - Pattern matching, efficiency issues, 499
  - Patterns, 85
    - alternatives in `(|)`, 97
    - conditions on, `Condition (/ ;)`, 92
    - finding expressions that match (`Cases`), 87
    - function arguments as structured, 344
    - in function definitions, 41, 88
    - matching (`MatchQ`), 86
    - matching sequence of expressions, 90
    - matching types of expressions, 87
    - named, 99
    - regular expressions, 332
    - repeated, 97–98, 549
    - structured, 88
    - syntactic vs. semantic matching, 89
  - Pentatonic scales, 448
  - Percolation, bond, 14
  - Perfect numbers, 152, 523
    - searching for, 11

- Permutations, 323
- Permutations of lists, 196
- Pi ( $\pi$ )
  - finding sequence of digits in, 110, 328
  - playing digits of, 401
  - random walks on digits of, 308, 396
- Pick, 127–128, 179, 428
- Piecewise, 212
- Piecewise functions, 4, 48
- Play, 397
- Plot, structure of, 374
- Points
  - in polygons, 419, 519
  - in two-dimensional graphics, `Point`, 369
  - multi-objects, 386
- `PointSize`, 369
- Polar representation of numbers, 263
- Polygons
  - finding points in convex, 420
  - finding points in nonconvex, 423, 519
  - interactive, 456, 477
  - regular, 12, 173
  - used to create hexagonal lattice, 395
- Polynomials
  - fast multiplication with Horner's method, 163
  - plotting complex solutions of, 446
  - testing for, `PolynomialQ`, 49
- Pooh, Charles, *xvii*
- `PopupMenu`, 453
- Porter's stemming algorithm, 340
- `Position`, 67–68, 100
- Postfix operators, 22
- Power grid, as graph, 63–64
- Precision
  - exact vs. approximate numbers, 269
  - fixed, 148, 274
  - high vs. machine, 271
  - of approximate numbers, `Precision`, 265
  - of internal algorithms, 278
  - setting, `SetPrecision`, 273
- `PrecisionGoal`, 278
- Predicates, 48
  - as pure functions, 157
- Prefix operators, 21
- `Prepend`, 75
- Previous output, 17
- Prime numbers, sieving, 224, 503
- `PrimePi`, 225
- `PrimeQ`, 48
- `Print`, 201, 280
- `Private`, 569
- Procedures, 189
- Profiling, 506, 520
- Programs
  - choosing efficient approach, 496
  - functional, 115
  - measuring efficiency of, 494
  - memory used in, 495
  - parallel, 515
  - profiling, 506, 520
- Protected attribute, `Protected`, 54
- `ProteinData`, 406
- Proteins
  - conformation of backbone, 6–7
  - dot plot, 363, 385
  - interaction networks, 177
  - visualization of, 406
- Pure functions, 153
  - as predicates, 157
  - efficiency issues, 509
  - listable, 508–509
  - nested, 158
  - sequence of arguments, (`##`), 377–378
- Quadrants, in Cartesian plane, 219
- Quadratic congruential method, for generating
  - random numbers, 264
- Radius of gyration tensor, 294
  - symbolic vs. numeric input, 505
  - visualization of, 295
- Random sparse arrays, 290
- Random numbers
  - from distributions, `RandomVariate`, 261
  - linear congruential generator, 264, 301
  - localizing generators, `BlockRandom`, 301
  - quadratic congruential generator, 264
  - seeding generators for, `SeedRandom`, 301
  - testing sequences of, 299
  - weighting choices, 263

- Random sampling
  - with replacement, `RandomChoice`, 145, 262
  - without replacement, `RandomSample`, 262, 315
- Random strings, 343, 361
- Random walks
  - across C major scale, 445
  - animation of, 469, 553
  - applications of, 534
  - as graphs, 554
  - bounded, 554
  - dynamic interfaces for, 469, 488
  - lattice walks, 264, 534
  - Lévy flights, 554
  - off-lattice, 187, 540
  - on digits of  $\pi$ , 308, 396, 554
  - on hexagonal lattice, 554
  - one-dimensional, 67, 137, 262
  - shape of, 294
  - square end-to-end distance, 574
  - three-dimensional, 539, 541
  - two-dimensional lattice, 80, 137, 152, 162, 536
  - using `GraphicsComplex`, 554
  - visualization of, 98–99, 446, 547
- `RandomChoice`, 145, 262
  - used to construct random strings, 345
- `RandomColor`, 131
- `RandomComplex`, 260
- `RandomInteger`, 260
- `RandomReal`, 260
- `RandomSample`, 145, 197, 262
- `RandomVariate`, 261
- Range, 59
- Rational numbers, 254
- Ray crossing algorithm, for point in polygon
  - problems, 420, 423
- Real numbers, 254
- `RealDigits`, 258
- Reap, 281
- Recursive definitions, 232
  - used to define higher-order functions, 238
  - with multiple arguments, 235
- `ReflectionTransform`, 375
- `RegionPlot`, 466
- Regression models, 436
- Regular expressions, 332
  - classes of characters in, 333
  - lookahead/lookbehind, 336
  - mixing with string patterns, 334
  - named patterns with, 334
  - referring to patterns in, 335
  - `RegularExpression`, 332
- Regular polygons, 12, 173
- Relational operators, 50
- Remove, 546
- Rep units, 162
- `Repeated` (.), 98, 412, 548–549
- `RepeatedNull` (.), 98
- Replacement rules, `ReplaceAll` (/.), 102
- `ReplacePart`, 76, 104, 287
- `ReplaceRepeated` (/./), 104
- Rest, 72
- Reverse, 74, 119
- Riffle, 142, 239
- Rolling dice, 264
- Root finding
  - bisection method, 206
  - Newton's method, 192
  - secant method, 293
- Root mean square distance, 294
- Root plots, 430
- Rotate, 133
- `RotateLeft`, 74, 175
- `RotateRight`, 74
- Rotoreliefs, 469
- Rules
  - delayed, `RuleDelayed` (:>), 103
  - getting information for, 44
  - rewrite, 44
  - user-defined, 44
- Run-length encoding, 246
- Runs tests, 302
- `SameQ` (===), 170, 255
- `SampleDepth`, 398
- `SampledSoundFunction`, 399
- `SampleRate`, 398
- `SaveDefinitions`, 465
- Sawtooth waves, 402
- Scale, of numbers, 267
- Scaling noises, 446

- Scoping, 146
  - localization of constants, `With`, 148, 176
  - localization of names, `Module`, 146
  - localization of values, `Block`, 147
  - tracing, 147
- Secant method
  - for Newton root-finding, 293
  - for root finding, 306
- `SeedRandom`, 301
- `Select`, 126, 179, 315
  - using pure functions with, 156
- Selection sort, 225–229
- Selectors, 37
- Semantics, definition of, 29
- Sequences, 90
  - subsequence search within, 109, 114, 328
- `SessionTime`, 388
- `Set (=)`, 42
- `SetAttributes`, 55, 208
- `SetDelayed (:=)`, 43
- `SetPrecision`, 273
- `SetSystemOptions`, 500
- Shannon, Claude, 265
- Sherlock, Tom, xvii
- `Short`, 374
- Shortest path problems, 415
- Shorthand notation
  - `&&`, `And`, 50
  - `@@`, `Apply`, 120
  - `/;`, `Condition`, 92, 211
  - `&`, `Function`, 154
  - `/@`, `Map`, 119
  - `||`, `Or`, 51
  - `/.`, `ReplaceAll`, 102
  - `//.`, `ReplaceRepeated`, 104
  - `;;`, `Span`, 70
  - `~~`, `StringExpression`, 325
  - `<>`, `StringJoin`, 317
  - `@@@`, applying at level one, 121
  - `[...]`, `Part`, 70
- Shuffling cards, 141
- Sierpinski triangle, 137
- Sieve of Eratosthenes, 224
  - improving efficiency of, 503
- Sign function, `Sign`, 218, 499
- Signal processing, Hamming distance, 170, 187, 514
- Simple closed paths, 415, 446
- Simplification
  - of trigonometric expressions, 3
  - using assumptions, 3
- `Sin`, dynamic visualization of, 468
- `Slider`, 472
- `Slider2D`, 453–454, 529
- `SlotSequence (##)`, 377–378
- Solving equations
  - differential, 3
  - increasing precision for, 253
  - van der Pol, 252
- Solving linear systems, 3
- `Sort`, 73, 119
- `SortBy`, 74, 179, 424
- Sorting, 225
  - animation of, 228–230
  - basic algorithm for lists, 111
  - bubble sort, 112, 229
  - computational complexity of, 112, 228
  - lists, 73
  - merge sort, 113, 244
  - points by base angles, 417
  - selection sort, 226
  - strings, 314
  - symbols, 112
- Sound, 396
  - chords, 400
  - of functions, `Play`, 397
  - of rational numbers, 398
  - physics of, 396
  - playing, `EmitSound`, 397
  - playing discrete amplitude levels, `ListPlay`, 399
  - primitives, `SoundNote`, 399
  - sample depth, `SampleDepth`, 398
  - sample rate, `SampleRate`, 398
  - sampling amplitude levels, 400
  - scaling, 445
  - setting duration of, 400
  - using MIDI instruments, 400
- `SoundNote`, 399
- `Sow`, 281
- Space-filling plots, 402
- `Span`, (`;;`), 70

- Sparse arrays, 32, 65, 282
  - converting to lists, `Normal`, 284
  - efficiency issues, 500–502
  - rules for, `ArrayRules`, 284
  - testing for symmetry of, 283
  - visualization of, `ArrayPlot`, 283
- `SparseArray`, 65, 282
- `Specularity`, 404
- Speed of light, 1
- `Sphere`, 367
- `Split`, 247
- Square waves, 401
- Standard deviation, 162, 385
  - visualization of, 427
- Starting *Mathematica*, 15
- Statistical tests, 298
  - autocorrelation, 304
  - fixed range, 301
  - frequency test, 299
  - NIST test suite, 303
  - runs test, 302
- Stem plots, 166
- Stemming words, 336
- Stop words, 342–343
- Stream plots, 5
- `StringCount`, 317
- `StringDrop`, 146, 317
- `StringExpression` (`~~`), 325
- `StringInsert`, 148, 317
- `StringJoin` (`<>`), 146, 317
- `StringMatchQ`, 325
- `StringPosition`, 317
- `StringReplace`, 317
- `StringReverse`, 146, 317
- Strings, 309
  - alternatives in patterns, 329
  - and Unicode, 313
  - changing case, 313
  - character codes, 312
  - concatenating, `StringJoin`, 146, 317
  - converting to Ascii, `ToCharacterCode`, 312
  - converting to symbols, 321
  - creating random, 343
  - encoding, 319
  - finding substrings, 349
  - in output, 310
  - length of, `StringLength`, 311
  - operations compared to lists, 318
  - operations on, 316
  - padding, 324
  - partitioning, 345
  - patterns for, 325
  - random, 343, 361
  - regular expressions for, 332
  - sorting characters in, 314
  - tests on, 311
  - trimming, 317
- `StringSplit`, 81, 328
  - alternative patterns with, 330
- `StringTake`, 316
- `StringTrim`, 317
- Structured patterns, 88, 344
- Subsets, testing for, 53
- Surfaces
  - reconstructing, 8–9
  - visualizing intersection of, 447
- `Switch`, 215
- `Switch` vs. `Which`, 216
- `Symbol`, 321
- Symbolic computation
  - basic, 2
  - compared with numeric, 392
- Symbols, converting from strings, 321
- `SymmetricMatrixQ`, 49, 283
- Syntax
  - alternative forms, 22
  - coloring for errors, 23
  - definition of, 29
  - for multiplication, 18–19
  - of functions, 19
- `SystemOptions`, 288–299, 500, 513
- `Table`, 59
  - creating nested lists with, 61
- `TableForm`, 62
- `TableView`, 10, 460, 482
- Tafjord, Oyvind, xvii
- `Take`, 71
- Term rewriting, 44



- Testing equality, `SameQ` vs. `Equal`, 170, 255
- Tests for randomness, 299
- `Text`, 372
- Text analysis
  - cleaning transcribed audio, 342
  - distribution of sentence lengths, 342
  - distribution of word lengths, 329–331
  - punctuation counts in, 361
  - stemming words, 336
  - stop words, 342–343
- Textures, for graphics, 5
- Thermoplasma volcanium*, GC content of, 355
- `Thread`, 122, 179
- `Ticks`, 371
- Time series
  - lags in data, 304
  - serial dependence in data, 308
  - statistical tests for, 304
  - visualization of, `Correlogram`, 305
  - visualization of trends in, 436
- Time value, of annuities, 4
- Timing, 494
- `ToBoxes`, 392
- `ToExpression`, 321
- `ToPackedArray`, 512
- `ToUpperCase`, 313, 317
- `TracePrint`, 173, 240
- Transformation rules, 102
  - Cartesian product example, 108
  - closed paths example, 105
  - compared with assignments, 102
  - counting change example, 104
  - dice visualization example, 109
  - finding maxima example, 107
  - syntax of, 102
- `Translate`, 134, 395
- `TranslationTransform`, 395
- Transposing
  - expressions, `Thread`, 123
  - lists, `Transpose`, 75, 428
  - matrices, 152
- Traveling salesman problems, 415
- `TreeForm`, 36
- Trend plots, 436
- Triangles
  - area of, 108, 421
  - dynamic with locators, 455
- Triangular numbers, 514
- Tridiagonal matrices, 290
- Truth tables, 50, 188
- Tryptophan, 405
- `Tube`, 7, 475
- Unicode, 313
- `Union`, 78
- Unique, 321
- `UpdateInterval`, 474
- Upper triangular matrices, 149, 218
  - efficiently generating, 502
- Usage messages, 413, 568
- van der Pol equations, 252
- van der Waals radius, 403
- Vandermonde matrix, 131
- Variables, definitions for, 41
- Vector field, stream plot, 5
- Vectors
  - divergence, 131–132
  - dot product, 125–126
  - normalizing, 489
  - of random numbers, 260
  - visualization of arithmetic for, 469
- Venn diagrams, 465, 468
- `VertexDegree`, 178
- `ViewPoint`, 479
- `ViewVertical`, 367
- von Neumann, John, 265
- von Neumann neighborhood, 537
- Warning messages, 167, 413
- `WeatherData`, 457–458, 469
- Web pages, scraping data from, 327, 342
- Weights, for random number generation, 263
- West, Mae, 365
- Whepley, Faisal, xvii
- `which`, 214, 542
- `while`, syntax of, 199
- `With`, 148, 176
  - compared to `Module`, 149–150



## Word games

anagrams, 322, 361

blanagrams, 359, 520

## Word stemming, 336

lemmatization, 341

Porter's algorithm, 340

## WordData, 315

displaying information from, 470

## Words

pluralizing, 342

singularizing, 340

stemming, 336

stop, 342–343

## WorkingPrecision, 278

Xor, ( $\vee$ ), 52

\$BaseDirectory, 557

\$Context, 558

\$ContextPath, 559

\$InstallationDirectory, 557

\$KernelID, 518

\$MachinePrecision, 266, 271

\$MaxMachineNumber, 271

\$MaxPrecision, 274

\$MinMachineNumber, 271

\$MinPrecision, 274

\$Path, 557

\$ProcessID, 518

\$ProcessorCount, 516

\$RecursionLimit, 245

\$UserBaseDirectory, 557