# Contents

Preface · page xi

1 An introduction to Mathematica
   1.1 Overview of basic operations · 1
       Numerical and symbolic computation · Graphics and visualization · Working with data · Dynamic interactivity · Programming
   1.2 Getting started · 14
       Starting up Mathematica · The notebook interface · Entering input · Mathematical expressions · Syntax of functions · Lists · Semicolons · Alternative input syntax · Comments · Errors · Getting out of trouble · The front end and the kernel
   1.3 Getting help · 25
       Function information · The Documentation Center

2 The Mathematica language
   2.1 Expressions · 29
       Types of expressions · Atoms · Structure of expressions · Evaluation of expressions · Exercises
   2.2 Definitions · 40
       Defining variables and functions · Immediate vs. delayed assignments · Term rewriting · Functions with multiple definitions · Exercises
   2.3 Predicates and Boolean operations · 48
       Predicates · Relational and logical operators · Exercises
   2.4 Attributes · 53
       Exercises
### 3 Lists

3.1 Creating and displaying lists · 58
   - List structure and syntax · List construction · Displaying lists · Arrays · Exercises

3.2 The structure of lists · 67
   - Testing a list · Measuring lists · Exercises

3.3 Operations on lists · 70
   - Extracting elements · Rearranging lists · List component assignment · Multiple lists · Exercises

### 4 Patterns and rules

4.1 Patterns · 85
   - Blanks · Pattern matching by type · Structured patterns · Sequence pattern matching · Conditional pattern matching · Alternatives · Repeated patterns · Functions that use patterns · Exercises

4.2 Transformation rules · 102
   - Creating and using replacement rules · Example: counting coins · Example: closed paths · Example: finding maxima · Exercises

4.3 Examples and applications · 109
   - Finding subsequences · Sorting a list · Exercises

### 5 Functional programming

5.1 Introduction · 116

5.2 Functions for manipulating expressions · 118
   - Map · Apply · Thread and MapThread · The Listable attribute · Inner and Outer · Select and Pick · Exercises

5.3 Iterating functions · 132
   - Nest · FixedPoint · NestWhile · Fold · Exercises

5.4 Programs as functions · 137
   - Building up programs · Example: shuffling cards · Compound functions · Exercises

5.5 Scoping constructs · 146
   - Localizing names: Module · Localizing values: Block · Localizing constants: With · Example: matrix manipulation · Exercises

5.6 Pure functions · 153
   - Syntax of pure functions · Using pure functions · Example: searching for attributes and options · Exercises
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.7</td>
<td>Options and messages</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Options · Messages · Exercises</td>
<td></td>
</tr>
<tr>
<td>5.8</td>
<td>Examples and applications</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Hamming distance · The Josephus problem · Regular graphs/polygons · Protein interaction networks · Palettes for project files · Operating on arrays · Exercises</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Procedural programming</td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Loops and iteration</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>Newton’s method · Do loops and For loops · Example: random permutations · While loops · NestWhile and NestWhileList · Exercises</td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>Flow control</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>Conditional functions · Piecewise-defined functions · Which and Switch · Argument checking · Exercises</td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>Examples and applications</td>
<td>219</td>
</tr>
<tr>
<td></td>
<td>Classifying points · Sieve of Eratosthenes · Sorting algorithms · Exercises</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Recursion</td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Fibonacci numbers</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>Exercises</td>
<td></td>
</tr>
<tr>
<td>7.2</td>
<td>Thinking recursively</td>
<td>234</td>
</tr>
<tr>
<td></td>
<td>Length of a list · Recursion with multiple arguments · Multiplying pairwise elements · Dealing cards, recursively · Finding maxima · Higher-order functions · Exercises</td>
<td></td>
</tr>
<tr>
<td>7.3</td>
<td>Dynamic programming</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>Exercises</td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td>Classical examples</td>
<td>244</td>
</tr>
<tr>
<td></td>
<td>Merge sort · Run-length encoding · Exercises</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Numerics</td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Numbers in Mathematica</td>
<td>251</td>
</tr>
<tr>
<td></td>
<td>Types of numbers · Digits and number bases · Random numbers · Exercises</td>
<td></td>
</tr>
<tr>
<td>8.2</td>
<td>Numerical computation</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>Precision and accuracy · Representation of approximate numbers · Exact vs. approximate numbers · High precision vs. machine precision · Computations with mixed number types · Working with precision and accuracy · Exercises</td>
<td></td>
</tr>
</tbody>
</table>
8.3 Arrays of numbers · 282
Sparse arrays · Packed arrays · Exercises

8.4 Examples and applications · 291
Newton's method revisited · Radius of gyration of a random walk · Statistical tests · Exercises

9 Strings
9.1 Structure and syntax · 310
Character codes · Sorting lists of characters · Ordered words · Exercises

9.2 Operations on strings · 316
Basic string operations · Strings vs. lists · Encoding text · Indexed symbols · Anagrams · Exercises

9.3 String patterns · 325
Finding subsequences with strings · Alternatives · Exercises

9.4 Regular expressions · 332
Word stemming · Exercises

9.5 Examples and applications · 343
Random strings · Partitioning strings · Adler checksum · Search for substrings · DNA sequence analysis · Displaying DNA sequences · Blanagrams · Exercises

10 Graphics and visualization
10.1 Structure of graphics · 365
Graphics primitives · Graphics directives · Graphics options · Combining graphics elements · Structure of built-in graphics functions · Example: Bézier curves · Example: hypocycloids · Exercises

10.2 Efficient structures · 386
Multi-objects · GraphicsComplex · Numeric vs. symbolic expressions · Exercises

10.3 Sound · 396
The sound of mathematics · Sound primitives and directives · Exercises

10.4 Examples and applications · 402
Space filling plots · Plotting lines in space · Simple closed paths · Points in a polygon · Visualizing standard deviations · Root plotting · Trend plots · Brownian music · Exercises

11 Dynamic expressions
11.1 Manipulating expressions · 449
Control objects · Control wrapper · Viewers · Animating the hypocycloid · Visualizing logical operators · Exercises
11.2 The structure of dynamic expressions · 470
  Dynamic · DynamicModule · Dynamic tips · Exercises

11.3 Examples and applications · 481
  Creating interfaces for visualizing data · File openers · Dynamic random walks · Apollonius’ circle · Exercises

12 Optimizing Mathematica programs
12.1 Measuring efficiency · 494
  Evaluation time · Memory storage

12.2 Efficient programs · 496
  Low-level vs. high-level functions · Pattern matching · Reducing size of computation · Symbolic vs. numeric computation · Listability · Pure functions · Packed arrays · Exercises

12.3 Parallel processing · 515
  Basic examples · Distributing definitions across subkernels · Profiling · Exercises

12.4 Compiling · 523
  Compile · Compiling to C · Exercises

13 Applications and packages
13.1 Random walk application · 534
  Lattice walks · Off-lattice walks · RandomWalk · Error and usage messages · Visualization · Animation · Exercises

13.2 Overview of packages · 555
  Working with packages · Package location

13.3 Contexts · 558

13.4 Creating packages · 563
  Package framework · Creating and installing the package · RandomWalks package · Running the package · Exercises
Solutions to exercises

2  The Mathematica language · 575
3  Lists · 578
4  Patterns and rules · 582
5  Functional programming · 588
6  Procedural programming · 614
7  Recursion · 621
8  Numerics · 626
9  Strings · 638
10  Graphics and visualization · 651
11  Dynamic expressions · 666
12  Optimizing Mathematica programs · 676
13  Applications and packages · 681

Bibliography · 687

Index · 695