Contents

Preface xii

1 Introduction 1

1.1 What Is MATLAB? 1
1.2 Does MATLAB Do Symbolic Calculations? 3
1.3 Will MATLAB Run on My Computer? 3
1.4 Where Do I Get MATLAB? 4
1.5 How Do I Use This Book? 4
1.6 Basics of MATLAB 5
1.6.1 MATLAB windows 5
1.6.2 On-line help 7
1.6.3 Input–output 7
1.6.4 File types 10
1.6.5 Platform dependence 10
1.6.6 General commands you should remember 12
1.7 Visit This Again 13

2 Tutorial Lessons 15

The Basics 16
2.1 Lesson 1: A Minimum MATLAB Session 17
2.2 Lesson 2: Creating and Working with Arrays of Numbers 21
2.3 Lesson 3: Creating and Printing Simple Plots 25
2.4 Lesson 4: Creating, Saving, and Executing a Script File 29
2.5 Lesson 5: Creating and Executing a Function File 33
Directional Explorations 38
2.6 Lesson 6: Working with Arrays and Matrices 39
2.7 Lesson 7: Working with Anonymous Functions 43
2.8 Lesson 8: Importing and Exporting Data 47
2.9 Lesson 9: Working with Files and Directories 51
2.10 Lesson 10: Publishing Reports 54
2.11 Lesson 11: Symbolic Computation 58

3 Interactive Computation **63**
3.1 Matrices and Vectors . . . 65
3.1.1 Input . . . 65
3.1.2 Indexing (or subscripting) . . . 66
3.1.3 Matrix manipulation . . . 66
3.1.4 Utility matrices . . . 70
3.1.5 Creating vectors with `linspace` and `logspace` . . . 72
3.2 Matrix and Array Operations . . . 73
3.2.1 Arithmetic operations . . . 73
3.2.2 Relational operations . . . 74
3.2.3 Logical operations . . . 74
3.2.4 Elementary math functions . . . 75
3.2.5 Matrix functions . . . 77
3.3 Character Strings . . . 77
3.3.1 Manipulating character strings . . . 79
3.3.2 The `eval` function . . . 80
3.4 A Special Note on Array Operations . . . 81
3.4.1 Vectorization . . . 82
3.5 Command-Line Functions . . . 83
3.5.1 Anonymous functions . . . 83
3.6 Using Built-in Functions and On-line Help . . . 85
3.6.1 Example 1: Finding the determinant of a matrix . . . 87
3.6.2 Example 2: Finding eigenvalues and eigenvectors . . . 87
3.7 Saving and Loading Data . . . 90
3.7.1 Saving into and loading from the binary Mat-files . . . 90
3.7.2 Importing data files . . . 91
3.7.3 Recording a session with `diary` . . . 92
3.8 Plotting Simple Graphs . . . 92
3.9 Fun with Functions Using `funtool` . . . 98

4 Programming in MATLAB: Scripts and Functions **101**
4.1 Script Files . . . 101
4.2 Function Files . . . 104
4.2.1 Executing a function . . . 105
4.2.2 More on functions . . . 107
4.2.3 MATLAB code analyzer . . . 110
4.2.4 Subfunctions . . . 111
4.2.5 Nested functions . . . 112
4.2.6 Compiled (parsed) functions: The p-code . . . 112
4.2.7 The profiler . . . 113
4.3 Language-specific Features . . . 113
4.3.1 Use of comments to create on-line help . . . 113
4.3.2 Continuation . . . 114
4.3.3 Global variables . . . 114

4.3.4 Loops, branches, and control-flow 116
4.3.5 Interactive input 119
4.3.6 Recursion 121
4.3.7 Input/output 121
4.4 Advanced Data Objects 123
4.4.1 Multidimensional matrices 123
4.4.2 Structures 124
4.4.3 Cells 128
4.4.4 Tables 131
4.5 Publishing Reports 135

5 Graphics **141**
5.1 Basic 2-D Plots 141
5.1.1 Style options 142
5.1.2 Labels, title, legend, and other text objects 142
5.1.3 Axis control, zoom in, and zoom out 143
5.1.4 Modifying plots with the plot editor 144
5.1.5 Overlay plots 144
5.1.6 Using `subplot` for Multiple Graphs 147
5.1.7 Specialized 2-D plots 149
5.2 3-D Plots 155
5.2.1 Mesh and surface plots 156
5.2.2 View 164
5.2.3 Rotate view 166
5.2.4 Vector field and volumetric plots 166
5.2.5 Interpolated surface plots 168
5.3 Handle Graphics 171
5.3.1 The object hierarchy 171
5.3.2 Object handles 172
5.3.3 Object properties 173
5.3.4 Modifying an existing plot 176
5.3.5 Complete control over the graphics layout 178
5.4 Fun with 3-D Surface Graphics 181
5.4.1 Generating a cylindrical surface 181
5.4.2 Face color, transparency, and light reflection 181
5.4.3 A little more fun with color and lighting 183
5.4.4 A word about choosing colors 184
5.5 Saving and Printing Graphs 185
5.5.1 Saving graphs to reusable files 186
5.6 Animation 187
5.6.1 Dynamic data plotting with Comet plot 187
5.6.2 Movies with a series of figure frames 187
5.6.3 Handle Graphics, the real animator 188
5.6.4 Handle Graphics functions for transforming a group of objects 194

Applications 197

6 Algebraic Equations 199

6.1 Linear Algebra . . . 199
6.1.1 Solving a linear system . . . 199
6.1.2 Gaussian elimination . . . 200
6.1.3 Finding eigenvalues and eigenvectors . . . 202
6.1.4 Generalized eigenvalue problem . . . 203
6.1.5 Matrix factorizations . . . 205
6.1.6 Advanced topics . . . 206
6.2 Nonlinear Algebraic Equations . . . 207
6.2.1 Roots of polynomials . . . 209

7 Data Analysis and Regression 213

7.1 Curve Fitting and Regression Analysis . . . 213
7.1.1 Polynomial curve fitting on the fly . . . 213
7.1.2 Do it yourself: Curve fitting with polynomial functions . . . 216
7.1.3 Nonlinear regression and least squares curve fitting . . . 218
7.1.4 General nonlinear fits . . . 221
7.1.5 Interpolation . . . 221
7.2 Correlations . . . 224
7.2.1 Goodness of fit or the coefficient of determination, r^2 . . . 226
7.3 Statistics . . . 227

8 Differential Equations 231

8.1 Numerical Integration (Quadrature) . . . 232
8.1.1 2-D and 3-D integration . . . 237
8.2 Solution of ODEs for Initial Value Problems . . . 239
8.2.1 Example 1: A first-order linear ODE . . . 240
8.2.2 Example 2: A second-order nonlinear ODE . . . 241
8.2.3 `ode23` versus `ode45` . . . 243
8.2.4 Specifying tolerance . . . 245
8.2.5 The ODE suite . . . 246
8.2.6 Event location . . . 248
8.3 Solution of ODEs for Boundary Value Problems . . . 252
8.3.1 Example 1: A simple BVP . . . 255
8.3.2 Example 2: Deflection of a fixed–fixed beam under nonuniform loading . . . 257
8.4 Advanced Topics . . . 259

9 Computer Algebra and the Symbolic Math Toolbox 263
9.1 The Symbolic Math Toolbox 263
9.1.1 Should you buy it? 264
9.1.2 Two useful tools in the Symbolic Math Toolbox 264
9.2 Numeric Versus Symbolic Computation 265
9.2.1 Variable precision arithmetic 266
9.3 Getting Help with the Symbolic Math Toolbox 266
9.4 Using the Symbolic Math Toolbox 268
9.4.1 Basic manipulations 268
9.4.2 Talking to itself 268
9.4.3 Generating MATLAB code for an anonymous function 270
9.4.4 Generating M-files from symbolic expressions 271
9.5 Using MuPAD Notebook 271
9.5.1 Graphics and animation 272
9.6 Summary: Some Symbolic Math Toolbox Commands 277

10 Errors 279

11 Honorable Mentions 284
11.1 Debugging Tools 284
11.2 External Interface: Mex-files 284
11.3 Graphical User Interface 284

A The MATLAB Language Reference 285
A.1 Punctuation Marks and Other Symbols 285
A.2 General-Purpose Commands 287
A.3 Special Variables and Constants 288
A.4 Language Constructs and Debugging 288
A.5 File Input/Output 288
A.6 Operators and Logical Functions 289
A.7 Frequently Used Math Functions 290
A.8 Matrices: Creation and Manipulation 291
A.9 Character String Functions 292
A.10 Graphics Functions 292
A.11 Some Applications Functions 294
A.11.1 Data analysis and Fourier transforms 294
A.11.2 Polynomials and data interpolation 294
A.11.3 Nonlinear numerical methods 294

Bibliography 295

Index 296