



MATLAB®
Programming
with
Applications
for Engineers

Stephen J. Chapman

620.00151
C466M
2013
c.1

International
Edition

Table of Contents

1.1	The Advantages of MATLAB	2
1.2	Disadvantages of MATLAB	4
1.3	The MATLAB Environment	4
1.3.1	The MATLAB Desktop	4
1.3.2	The Command Window	6
1.3.3	The Command History Window	7
1.3.4	The Start Button	7
1.3.5	The Edit/Debug Window	9
1.3.6	Figure Windows	9
1.3.7	Docking and Undocking Windows	11
1.3.8	The MATLAB Workspace	11
1.3.9	The Workspace Browser	12
1.3.10	Getting Help	13
1.3.11	A Few Important Commands	15
1.3.12	The MATLAB Search Path	17
1.4	Using MATLAB as a Calculator	19
1.5	Summary	21
1.5.1	MATLAB Summary	22
1.6	Exercises	22

Chapter 1 Introduction to MATLAB

1.1	The Advantages of MATLAB	2
1.2	Disadvantages of MATLAB	4
1.3	The MATLAB Environment	4
1.3.1	The MATLAB Desktop	4
1.3.2	The Command Window	6
1.3.3	The Command History Window	7
1.3.4	The Start Button	7
1.3.5	The Edit/Debug Window	9
1.3.6	Figure Windows	9
1.3.7	Docking and Undocking Windows	11
1.3.8	The MATLAB Workspace	11
1.3.9	The Workspace Browser	12
1.3.10	Getting Help	13
1.3.11	A Few Important Commands	15
1.3.12	The MATLAB Search Path	17
1.4	Using MATLAB as a Calculator	19
1.5	Summary	21
1.5.1	MATLAB Summary	22
1.6	Exercises	22

Chapter 2 MATLAB Basics

25

2.1	Variables and Arrays	25
2.2	Creating and Initializing Variables in MATLAB	29
2.2.1	Initializing Variables in Assignment Statements	29
2.2.2	Initializing with Shortcut Expressions	32
2.2.3	Initializing with Built-in Functions	33
2.2.4	Initializing Variables with Keyboard Input	33
2.3	Multidimensional Arrays	35
2.3.1	Storing Multidimensional Arrays in Memory	37
2.3.2	Accessing Multidimensional Arrays with One Dimension	37
2.4	Subarrays	39
2.4.1	The end Function	39
2.4.2	Using Subarrays on the Left-hand Side of an Assignment Statement	40
2.4.3	Assigning a Scalar to a Subarray	41
2.5	Special Values	42
2.6	Displaying Output Data	44
2.6.1	Changing the Default Format	44
2.6.2	The disp function	46
2.6.3	Formatted output with the fprintf function	46
2.7	Data Files	48
2.8	Scalar and Array Operations	50
2.8.1	Scalar Operations	51
2.8.2	Array and Matrix Operations	51
2.9	Hierarchy of Operations	54
2.10	Built-In MATLAB Functions	57
2.10.1	Optional Results	58
2.10.2	Using MATLAB Functions with Array Inputs	58
2.10.3	Common MATLAB Functions	58
2.11	Introduction to Plotting	60
2.11.1	Using Simple xy Plots	61
2.11.2	Printing a Plot	62
2.11.3	Exporting a Plot as a Graphical Image	62
2.11.4	Saving a Plot in a Figure File	63
2.11.5	Multiple Plots	63
2.11.6	Line Color, Line Style, Marker Style, and Legends	64
2.12	Examples	68
2.13	MATLAB Applications: Vector Mathematics	74
2.13.1	Vector Addition and Subtraction	76
2.13.2	Vector Multiplication	77
2.14	MATLAB Applications: Matrix Operations and Simultaneous Equations	81
2.14.1	The Matrix Inverse	82

2.15 Debugging MATLAB Programs	84
2.16 Summary	86
2.16.1 Summary of Good Programming Practice	86
2.16.2 MATLAB Summary	87
2.17 Exercises	90

Chapter 3 Two-Dimensional Plots 103

3.1 Additional Plotting Features for Two-Dimensional Plots	103
3.1.1 Logarithmic Scales	104
3.1.2 Controlling x- and y-axis Plotting Limits	107
3.1.3 Plotting Multiple Plots on the Same Axes	110
3.1.4 Creating Multiple Figures	111
3.1.5 Subplots	111
3.1.6 Controlling the Spacing Between Points on a Plot	114
3.1.7 Enhanced Control of Plotted Lines	117
3.1.8 Enhanced Control of Text Strings	118
3.2 Polar Plots	121
3.3 Annotating and Saving Plots	123
3.4 Additional Types of Two-Dimensional Plots	126
3.5 Using the <code>plot</code> function with Two-Dimensional Arrays	131
3.6 Summary	133
3.6.1 Summary of Good Programming Practice	134
3.6.2 MATLAB Summary	134
3.7 Exercises	135

Chapter 4 Branching Statements and Program Design 139

4.1 Introduction to Top-Down Design Techniques	140
4.2 Use of Pseudocode	143
4.3 Relational and Logic Operators	144
4.3.1 Relational Operators	144
4.3.2 A Caution About The <code>==</code> And <code>~=</code> Operators	146
4.3.3 Logic Operators	147
4.3.4 Logical Functions	151
4.4 Branches	153
4.4.1 The <code>if</code> Construct	154
4.4.2 Examples Using <code>if</code> Constructs	156
4.4.3 Notes Concerning the Use of <code>if</code> Constructs	162
4.4.4 The <code>switch</code> Construct	164
4.4.5 The <code>try/catch</code> Construct	166
4.5 More on Debugging MATLAB Programs	173
4.6 MATLAB Applications: Roots of Polynomials	178

4.7	Summary	181
4.7.1	Summary of Good Programming Practice	181
4.7.2	MATLAB Summary	182
4.8	Exercises	182

Chapter 5 Loops and Vectorization

189

5.1	The while Loop	189
5.2	The for Loop	195
5.2.1	Details of Operation	202
5.2.2	Vectorization: A Faster Alternative to Loops	204
5.2.3	The MATLAB Just-In-Time (JIT) Compiler	205
5.2.4	The break and continue Statements	208
5.2.5	Nesting Loops	210
5.3	Logical Arrays and Vectorization	212
5.3.1	Creating the Equivalent of if/else Constructs with Logical Arrays	213
5.4	The MATLAB Profiler	215
5.5	Additional Examples	217
5.6	The textread Function	222
5.7	MATLAB Applications: Statistical Functions	234
5.8	MATLAB Applications: Curve Fitting and Interpolation	237
5.8.1	General Least-Squares Fits	237
5.8.2	Cubic Spline Interpolation	244
5.8.3	Interactive Curve-Fitting Tools	250
5.9	Summary	253
5.9.1	Summary of Good Programming Practice	254
5.9.2	MATLAB Summary	254
5.10	Exercises	255

Chapter 6 Basic User-Defined Functions

267

6.1	Introduction to MATLAB Functions	269
6.2	Variable Passing in MATLAB: The Pass-By-Value Scheme	274
6.3	Optional Arguments	285
6.4	Sharing Data Using Global Memory	290
6.5	Preserving Data Between Calls to a Function	298
6.6	MATLAB Applications: Sorting Functions	303
6.7	MATLAB Applications: Random Number Functions	305
6.8	Summary	306
6.8.1	Summary of Good Programming Practice	306
6.8.2	MATLAB Summary	306
6.9	Exercises	307

Chapter 7 Advanced Features of User-Defined Functions**317**

-
- 7.1 Function Functions 317**
 - 7.2 Subfunctions and Private Functions 321**
 - 7.2.1 Subfunctions 322
 - 7.2.2 Private Functions 323
 - 7.2.3 Order of Function Evaluation 324
 - 7.3 Function Handles 324**
 - 7.3.1 Creating and Using Function Handles 324
 - 7.4 Anonymous Functions 327**
 - 7.5 Recursive Functions 328**
 - 7.6 Plotting Functions 329**
 - 7.7 Histograms 332**
 - 7.8 Summary 337**
 - 7.8.1 Summary of Good Programming Practice 337
 - 7.8.2 MATLAB Summary 337
 - 7.9 Exercises 338**

Chapter 8 Complex Numbers and 3D Plots**345**

-
- 8.1 Complex Data 345**
 - 8.1.1 Complex Variables 347
 - 8.1.2 Using Complex Numbers with Relational Operators 348
 - 8.1.3 Complex Functions 348
 - 8.1.4 Plotting Complex Data 354
 - 8.2 Multidimensional Arrays 358**
 - 8.3 Three-Dimensional Plots 360**
 - 8.3.1 Three-Dimensional Line Plots 360
 - 8.3.2 Three-Dimensional Surface, Mesh, and Contour Plots 362
 - 8.3.3 Creating Three-Dimensional Objects using Surface and Mesh Plots 367
 - 8.4 Summary 370**
 - 8.4.1 Summary of Good Programming Practice 370
 - 8.4.2 MATLAB Summary 371
 - 8.5 Exercises 371**

Chapter 9 Cell Arrays, Structures, and Importing Data 375

-
- 9.1 Cell Arrays 375**
 - 9.1.1 Creating Cell Arrays 377
 - 9.1.2 Using Braces {} as Cell Constructors 379
 - 9.1.3 Viewing the Contents of Cell Arrays 379

9.1.4	Extending Cell Arrays	380
9.1.5	Deleting Cells in Arrays	382
9.1.6	Using Data in Cell Arrays	383
9.1.7	Cell Arrays of Strings	383
9.1.8	The Significance of Cell Arrays	384
9.1.9	Summary of <code>cell</code> Functions	388
9.2	Structure Arrays	388
9.2.1	Creating Structure Arrays	390
9.2.2	Adding Fields to Structures	392
9.2.3	Removing Fields from Structures	392
9.2.4	Using Data in Structure Arrays	393
9.2.5	The <code>getfield</code> and <code>setfield</code> Functions	394
9.2.6	Dynamic Field Names	395
9.2.7	Using the <code>size</code> Function with Structure Arrays	397
9.2.8	Nesting Structure Arrays	397
9.2.9	Summary of structure Functions	398
9.3	Importing Data into MATLAB	403
9.4	Summary	405
9.4.1	Summary of Good Programming Practice	406
9.4.2	MATLAB Summary	406
9.5	Exercises	406

Chapter 10 Handle Graphics and Animation

411

10.1	Handle Graphics	411
10.1.1	The MATLAB Graphics System	411
10.1.2	Object Handles	413
10.1.3	Examining and Changing Object Properties	413
10.1.4	Using <code>set</code> to List Possible Property Values	420
10.1.5	Finding Objects	422
10.1.6	Selecting Objects with the Mouse	424
10.2	Position and Units	426
10.2.1	Positions of figure Objects	427
10.2.2	Positions of axes Objects	428
10.2.3	Positions of text Objects	428
10.3	Printer Positions	431
10.4	Default and Factory Properties	431
10.5	Graphics Object Properties	434
10.6	Animations and Movies	434
10.6.1	Erasing and Redrawing	434
10.6.2	Creating a Movie	439
10.7	Summary	441
10.7.1	Summary of Good Programming Practice	441
10.7.2	MATLAB Summary	442
10.8	Exercises	442

Chapter 11 More MATLAB Applications 447

11.1 Solving Systems of Simultaneous Equations	447
11.1.1 Possible Solutions of Simultaneous Equations	449
11.1.2 Determining the Existence and Uniqueness of Solutions	451
11.1.3 Well-Conditioned Versus Ill-Conditioned Systems of Equations	452
11.1.4 Solving Systems of Equations with Unique Solutions	454
11.1.5 Solving Systems of Equations with an Infinite Number of Solutions	456
11.1.6 Solving Overdetermined Systems of Equations	460
11.2 Differences and Numerical Differentiation	463
11.3 Numerical Integration—Finding the Area Under a Curve	466
11.4 Differential Equations	472
11.4.1 Deriving Differential Equations for a System	473
11.4.2 Solving Ordinary Differential Equations in MATLAB	476
11.4.3 Applying <code>ode45</code> to Solve for the Voltage in a Circuit	480
11.4.4 Solving Systems of Differential Equations	482
11.4.5 Solving Higher Order Differential Equations	486
11.4.6 Stiff Differential Equations	489
11.5 Summary	490
11.5.1 Summary of Good Programming Practice	491
11.5.2 MATLAB Summary	492
11.6 Exercises	492

Appendix A ASCII Character Set 499

Appendix B Additional MATLAB Input/Output Functions 501

B.1 MATLAB File Processing	501
B.2 File Opening and Closing	503
B.2.1 The <code>fopen</code> Function	503
B.2.2 The <code>fclose</code> Function	505
B.3 Binary I/O Functions	506
B.3.1 The <code>fwrite</code> Function	506
B.3.2 The <code>fread</code> Function	507
B.4 Formatted I/O Functions	510
B.4.1 The <code>fprintf</code> Function	510
B.4.2 Understanding Format Conversion Specifiers	512
B.4.3 The <code>scanf</code> Function	514
B.4.4 The <code>fgetl</code> Function	516
B.4.5 The <code>fgets</code> Function	516
B.5 The <code>textscan</code> Function	516

Appendix C Working with Character Strings 519

C.1 String Functions	519
C.1.1 String Conversion Functions	520
C.1.2 Creating Two-Dimensional Character Arrays	520
C.1.3 Concatenating Strings	521
C.1.4 Comparing Strings	521
C.1.5 Searching and Replacing Characters within a String	525
C.1.6 Uppercase and Lowercase Conversion	526
C.1.7 Trimming Whitespace from Strings	527
C.1.8 Numeric-to-String Conversions	527
C.1.9 String-to-Numeric Conversions	529
C.1.10 Summary	530
C.2 Summary	536
C.2.1 Summary of Good Programming Practice	536
C.2.2 MATLAB Summary	537
C.3 Exercises	538

Appendix D Answers to Quizzes 539

Index	555
--------------	------------