

TABLE OF CONTENTS

ABOUT THE AUTHORS	x
PREFACE	xiv

MODULE 1: INITIAL SETUP AND BASIC OPERATION

Lesson 1.1 – MATLAB Introduction	2
What is MATLAB?	2
What is MATLAB used for in engineering and science?	2
How can I get MATLAB onto my computer?	3
Are there any free alternatives to MATLAB?	3
Where can I find more information and help with MATLAB online?	3
Lesson 1.2 – Hello World	4
Where can I find and open the MATLAB program?	4
Step 1: Create a New m-file	4
Step 2: Write the ‘Hello World’ Code	5
Step 3: Run the Program	6
Step 4: Make Your Program a Little Fancier	6
Lesson 1.3 – MATLAB Environment	8
MATLAB Environment Windows and Parts	8
Navigation Ribbon	9
Working Folder Location	9
Current Folder	10
Command Window	10
Editor Window	11
Workspace	11
Status Bar	12
Lesson 1.4 – Changing MATLAB Preferences	13
How can I change the window layout in MATLAB?	13
Changing Basic User Preferences	14
Lesson 1.5 – The m-file	16
What is an m-file?	16
Where can I create a new m-file?	17
How do I save my m-file?	17
How do I input variables and expressions into the m-file?	17
How do I run the m-file?	18
What are the clc and clear commands?	19
How can I place comments in my m-file?	19
Can I separate my code into parts within the m-file?	20
What does the color highlighting in the m-file mean?	20
Multiple Choice Quiz	22

Exercises	23
Lesson 1.6 – The Command Window	27
What is the Command Window and how can I use it?	27
How can I suppress outputs in the Command Window?	28
Can I view help from the Command Window?	29
Can the Command Window do it all?	30
Multiple Choice Quiz	31
Exercises	32
Lesson 1.7 – Publishing an m-file	33
What does publishing do?	33
How can I publish in MATLAB?	34
How can I get a PDF file of my published code?	34
 MODULE 2: BASIC PROGRAMMING FUNDAMENTALS	
Lesson 2.1 – Variables and Naming Rules	38
What is a mathematical variable?	38
What is a programming variable?	38
How can I give my results a variable name of their own?	38
What are some possible problems with naming an expression?	40
Are there benefits to good practices for variable naming?	41
Are there some guidelines for variable naming that I can follow?	42
Multiple Choice Quiz	45
Exercises	47
Lesson 2.2 – Characters and Strings	48
What is a character?	48
What is a string?	49
What makes characters/strings special?	50
Multiple Choice Quiz	52
Exercises	54
Lesson 2.3 – Working with Strings	55
How do I join two strings together?	55
How do I search and count strings?	56
How do I make a whole string lower or upper case?	57
Can I split a string into its component pieces?	58
Multiple Choice Quiz	61
Exercises	63
Lesson 2.4 – Inputs and Outputs	64
How can I get an input from the user?	64
How do I display notes in the Command Window?	64
Multiple Choice Quiz	69
Exercises	71
Lesson 2.5 – Data Types	73
What is a data type?	73

What are the MATLAB data types?	73
Why are data types important?	74
How do I check the data type of a variable?	74
Can I convert between data types?	76
Multiple Choice Quiz	80
Exercises	81
Lesson 2.6 – Vectors and Matrices	82
Why is the program called MATLAB?	82
What is a matrix?	82
Do I need to know any special types of matrices?	83
What is a vector?	83
How do I define a vector or a matrix in MATLAB?	84
What are some basic functions and commands for matrix manipulation?	86
How can I reference strings as vectors?	89
Multiple Choice Quiz	91
Exercises	93
Lesson 2.7 – How to Debug Code	94
What is an error?	94
What is a warning?	95
How can I solve the problem with my code?	95
Can I pause my program part of the way through?	98
What if I cannot find the exact place of the error?	100
Multiple Choice Quiz	101
Exercises	102

MODULE 3: PLOTTING

Lesson 3.1 – Plots and Figures	106
How can I visualize (plot) data in MATLAB?	106
How do I plot data pairs (points) in MATLAB?	106
How do I plot a function in MATLAB?	107
What is the difference between a figure and a plot?	109
How can I enter nonlinear functions for plotting?	109
What are some possible errors with plotting?	110
How do I show multiple data sets on the same plot?	110
What are some other types of plots that MATLAB can generate?	112
How do I plot on more than one figure in the same m-file?	113
What is the close all command?	114
Multiple Choice Quiz	115
Exercises	117
Lesson 3.2 – Plot Formatting	119
How can my MATLAB graph look nicer?	119
What are some terms I should know for plots?	119
How can I change the color and style of lines and markers on a plot?	120

How can I make the function and points on the graph look nicer?	121
How can I put a title and axis labels on my plot?	123
How can I add a legend to my plot?	123
How can I add a grid to my graph?	124
How can I add special characters in my axis labels and title?	125
How can I change axis limits and tick labels?	126
Multiple Choice Quiz	129
Exercises	130
Lesson 3.3 – Advanced Plotting	132
Does MATLAB have more plotting capabilities?	132
How can I create a bar graph?	132
How can I create a 3D line plot?	134
How can I create a 3D surface plot?	135
How can I create a polar plot?	138
Multiple Choice Quiz	141
Exercises	142
MODULE 4: MATH AND DATA ANALYSIS	
Lesson 4.1 – Basic Algebra, Logarithms, and Trigonometry	144
What kind of mathematical functions and operations are available in MATLAB?	144
How do I use logarithmic functions in MATLAB?	144
What about a logarithm that is not natural?	146
How can MATLAB evaluate trigonometric functions?	147
Multiple Choice Quiz	151
Exercises	152
Lesson 4.2 – Symbolic Variables	155
What is a symbolic variable?	155
What is a MATLAB toolbox?	155
How do I use symbolic variables?	155
How do I clear specific variables?	157
How can I convert from syms data type to other data types?	157
Can I replace a symbolic variable with a value?	158
How can I change the output format of syms?	159
Multiple Choice Quiz	161
Exercises	163
Lesson 4.3 – Solution of Linear and Nonlinear Equations	165
How do I solve for roots of a linear equation?	165
What is a nonlinear equation?	166
How can I use MATLAB to solve nonlinear equations?	167
Is there a faster way to work with polynomial equations in MATLAB?	171
Can I plot with symbolic variables?	172
Multiple Choice Quiz	174

Exercises	175
Lesson 4.4 – Differential Calculus	179
What is a derivative?	179
How do I take the derivative of a function in MATLAB?	180
Where are derivatives used in engineering?	183
How do I find the derivative of a discrete function in MATLAB?	184
Multiple Choice Quiz	187
Exercises	189
Lesson 4.5 – Integral Calculus	191
What is integration?	191
How does MATLAB conduct symbolic integration?	192
Can MATLAB do numerical integration?	194
Multiple Choice Quiz	197
Exercises	199
Lesson 4.6 – Linear Algebra	202
What is linear algebra?	202
How do I add and subtract matrices?	202
Can I use math functions like sin() on matrices?	203
How do I perform matrix multiplication?	205
What is the difference between matrix and array operations?	205
How do I take the inverse of a matrix?	208
Can MATLAB do advanced matrix and vector operations?	210
How can I solve systems of equations with MATLAB?	213
Multiple Choice Quiz	219
Exercises	220
Lesson 4.7 – Curve Fitting	222
What is curve fitting?	222
What is interpolation?	222
How can I interpolate data in MATLAB?	222
What is spline interpolation?	225
How do I conduct spline interpolation?	226
What is regression?	228
How do I do regression in MATLAB?	229
Multiple Choice Quiz	233
Exercises	235
Lesson 4.8 – Curve Fitting – Plotting	238
How can I plot the results of curve fitting?	238
What are some common mistakes when plotting curve fitting results?	242
Multiple Choice Quiz	244
Exercises	246
Lesson 4.9 – Ordinary Differential Equations	249
What is a differential equation?	249
How do I set up and solve a differential equation?	250
How do I solve a higher order ODE?	251

What are the limitations of using the dsolve() function?	253
Multiple Choice Quiz	254
Exercises	256

MODULE 5: CONDITIONAL STATEMENTS

Lesson 5.1 – Conditions and Boolean Logic	260
What are conditions?	260
What is Boolean logic?	262
Can different data types be identified in MATLAB?	264
How can I round numbers in MATLAB?	265
Multiple Choice Quiz	268
Exercises	269
Lesson 5.2 – Conditional Statements: if and if-else	270
What is a conditional statement?	270
What is the if statement?	270
What is the if-else statement?	273
Can I use multiple conditions in a single expression?	275
A Note on Writing Good Conditions	278
Multiple Choice Quiz	279
Exercises	281
Lesson 5.3 – Conditional Statements: if-elseif	284
What is the if-elseif statement?	284
Independent vs. Dependent Cases	286
What is the if-elseif-else statement?	288
What is the difference between the else and elseif conditional clauses?	290
Multiple Choice Quiz	291
Exercises	293

MODULE 6: PROGRAM DESIGN AND COMMUNICATION

Lesson 6.1 – Flowcharts	298
What is a flowchart?	298
Multiple Choice Quiz	304
Exercises	306
Lesson 6.2 – Pseudocode	308
What is a pseudocode?	308
How are pseudocodes used?	308
How can I convert a pseudocode for a problem into a program?	310
Multiple Choice Quiz	312
Exercises	313
Lesson 6.3 – Writing Better Code	314
How can I improve my code for computational efficiency?	314

How does hardcoding impact a program?	317
What are some tips for good comments and spacing?	317
Why does proper code indenting matter?	318
What are some tips for choosing inputs and outputs?	318
What are some tips for thinking ahead in when designing my program?	318

MODULE 7: FUNCTIONS

Lesson 7.1 – User-Defined Functions	320
What is a function?	320
What are the naming rules for functions in MATLAB?	320
How can I create functions in MATLAB?	321
Can I define functions in the program m-file?	325
Multiple Choice Quiz	331
Exercises	333
Lesson 7.2 – Function Design and Communication	338
How can I add a description for my function?	338
How can I define errors and warnings inside my function?	339
Multiple Choice Quiz	342
Exercises	343

MODULE 8: LOOPS

Lesson 8.1 – while Loops	346
What is a loop?	346
What is a while loop?	347
What comparisons can I use with a while loop?	353
Multiple Choice Quiz	357
Exercises	360
Lesson 8.2 – for Loops	363
What is a for loop?	363
How can I reference vectors inside of a loop?	367
Do I have to use the loop counter variable in the body of the loop?	370
When do I use a for loop vs. a while loop?	372
Multiple Choice Quiz	375
Exercises	378
Lesson 8.3 – break and continue Commands	381
What are the break and continue commands?	381
How does the break command work in MATLAB?	381
How does the continue command work in MATLAB?	383
Multiple Choice Quiz	386
Exercises	389

Lesson 8.4 – Nested Loops	390
What is a nested loop?	390
How do nested loops work?	391
How do loop mechanics apply to nested loops?	392
What is a “flag”?	393
When should I use programming flags?	394
How can I use break and continue in nested loops?	396
Multiple Choice Quiz	399
Exercises	402
Lesson 8.5 – Working with Matrices and Loops	403
How can I reference matrices in a loop?	403
How do I store values in a matrix using a loop?	406
How can I access specific areas of a matrix?	409
What is vectorization?	415
How can I vectorize matrix operations in MATLAB?	416
What are some tips I can use for vectorization?	420
Multiple Choice Quiz	421
Exercises	424
Lesson 8.6 – Applied Loops	429
Why is this lesson important?	429
How can I sort an array?	429
How can I find the sum of a vector?	433
How can I plot different variations of a function using loops?	434
Multiple Choice Quiz	437
Exercises	440

MODULE 9: READING FROM AND WRITING TO FILES

Lesson 9.1 – Reading from Files	446
Why read data from a file?	446
How do I read numeric-only data from files?	446
What is a delimiter?	448
How can I read numeric and character data from files?	448
Multiple Choice Quiz	453
Exercises	454
Lesson 9.2 – Writing to Files	457
How can I write numeric data to files with MATLAB?	457
How can I write non-numeric data to files with MATLAB?	458
Multiple Choice Quiz	462
Exercises	463
Lesson 9.3 – Navigating Directories with MATLAB	465
How do I set the current working directory for MATLAB?	465
How can I loop through the contents of a directory?	467
How can I create a new folder (directory) with MATLAB?	470

Multiple Choice Quiz	472
Exercises	473
APPENDICES	
Appendix A – Matrix Algebra Primer	478
What is a matrix?	478
What are the special types of matrices?	479
Vector	479
Row Vector	479
Column Vector	479
Square Matrix	480
Trace of a Matrix	480
Upper Triangular Matrix	480
Lower Triangular Matrix	481
Diagonal Matrix	481
Identity Matrix	482
Zero Matrix	482
Tridiagonal Matrix	482
Diagonally Dominant Matrix	483
When are two matrices considered to be equal?	484
How do you add two matrices?	484
How do you subtract two matrices?	486
How do I multiply two matrices?	487
What is a scalar product of a constant and a matrix?	489
What is a linear combination of matrices?	490
What are some of the rules of binary matrix operations?	490
Commutative law of addition	490
Associate law of addition	491
Associate law of multiplication	491
Distributive law	491
Is $[A][B]=[B][A]$?	492
Transpose of a matrix	492
Symmetric matrix	493
Matrix algebra is used for solving a system of equations.	494
Can you divide two matrices?	496
Can I use the concept of the inverse of a matrix to find the solution of a set of equations $[A] [X] = [C]$?	497
How do I find the inverse of a matrix?	497
Appendix B – Mini Projects	501
Appendix C – Plot Animation	517