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978-1-107-66222-3 - A Guide to MATLAB<sup>®</sup>: for Beginners and Experienced Users: Third Edition

Brian R. Hunt, Ronald L. Lipsman and Jonathan M. Rosenberg

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# A Guide to MATLAB<sup>®</sup>

## for Beginners and Experienced Users

Third Edition

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# A Guide to MATLAB®

for Beginners and Experienced Users

Third Edition

*Updated for MATLAB® 8 and Simulink® 8*

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Brian R. Hunt

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All of the University of Maryland, College Park



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# Preface

MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java®.

– The MathWorks, Inc.

That statement encapsulates the view of The MathWorks, Inc., the developer of MATLAB®. MATLAB 8 is an ambitious program. It contains hundreds of commands to do mathematics. You can use it to graph functions, solve equations, perform statistical tests, and much more. It is a high-level programming language that can communicate with its cousins, e.g., Fortran and C. You can produce sound and animate graphics. You can do simulations and modeling (especially if you have access not just to basic MATLAB but also to its accessory Simulink®). You can do symbolic computations (if you have the Symbolic Math Toolbox and its included package, MuPAD®). You can prepare materials for export to the internet. In addition, you can use MATLAB to combine mathematical computations with text and graphics in order to produce a polished, integrated, interactive document.

A program this sophisticated contains many features and options. There are literally hundreds of useful commands at your disposal. The MATLAB help documentation contains thousands of entries. The standard references, whether the MathWorks User's Guide for the product, or any of our competitors, contain a myriad of tables describing an endless stream of commands, options, and features that the user might be expected to learn or access.

MATLAB is more than a fancy calculator; it is an extremely useful and versatile tool. Even if you know only a little about MATLAB, you can use it to accomplish wonderful things. The hard part, however, is figuring out which of the hundreds of commands, scores of help pages, and thousands of items of documentation you need to look at in order to start using it quickly and effectively.

That's where we come in.

## Why We Wrote This Book

The goal of this book is to get you started using MATLAB successfully and quickly. We point out the parts of MATLAB you need to know without overwhelming you with details. We help you avoid the rough spots. We give you examples of real uses

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of MATLAB that you can refer to when you're doing your own work. We provide a handy reference to the most useful features of MATLAB. When you've finished reading this book, you will be able to use MATLAB effectively. You'll also be ready to explore more of MATLAB on your own.

You might not be a MATLAB expert when you finish this book, but you will be prepared to become one – if that's what you want. We figure you're probably more interested in being an expert at your own specialty, whether that's finance or physics, psychology or engineering. You want to use MATLAB the way we do, as a tool. This book is designed to help you become a proficient MATLAB user as quickly as possible, so you can get on with the business at hand.

## Who Should Read This Book

This book will be useful to complete novices, occasional users who want to sharpen their skills, intermediate or experienced users who want to learn about the new features of MATLAB 8, or who want to learn how to use Simulink or MuPAD, and even experts who want to find out whether we know anything they don't.

You can read through this guide to learn MATLAB on your own. If your employer (or your professor) has plopped you in front of a computer with MATLAB and told you to learn how to use it, then you'll find the book particularly useful. If you are teaching or taking a course in which you want to use MATLAB as a tool to explore another subject – whether in mathematics, science, engineering, business, or statistics – this book will make a perfect supplement.

As mentioned, we wrote this guide for use with MATLAB 8. If you plan to continue using MATLAB 7, however, you can still profit from this book. Virtually all of the material on MATLAB commands in this book applies to all these versions. The primary features of MATLAB 8 not found in earlier versions have to do with the Desktop interface, the Editor/Debugger, and interaction between MATLAB and MuPAD in the Symbolic Math Toolbox.

## How This Book Is Organized

In writing, we used our experience to focus on providing important information as quickly as possible. The book contains a short, focused introduction to MATLAB. It contains practice problems (with complete solutions) so you can test your knowledge. There are several illuminating sample projects that show you how MATLAB can be used in real-world applications and an entire chapter on troubleshooting.

The core of this book consists of about 65 pages: Chapters 1–4, and the beginning of Chapter 5. Read that much and you'll have a good grasp of the fundamentals of MATLAB. Read the rest – the remainder of the Graphics chapter as well as the chapters on Programming, Publishing, MuPAD, Simulink, GUIs, Applications, Troubleshooting, and the Glossary – and you'll know enough to do a great deal with MATLAB.

Here is a detailed summary of the contents of the book.

Chapter 1, *Getting Started*, describes how to start MATLAB on various platforms. It tells you how to enter commands, how to access online help, how to recognize the

various MATLAB windows you will encounter, and how to exit the application.

Chapter 2, *MATLAB Basics*, shows you how to do elementary mathematics using MATLAB. This chapter contains the most essential MATLAB commands.

Chapter 3, *Interacting with MATLAB*, contains an introduction to the MATLAB Desktop interface. This chapter will introduce you to the basic window features of the application, to the small program files (M-files) that you will use to make the most effective use of the software, and to a few methods for presenting the results of your MATLAB sessions. After completing this chapter, you'll have a better appreciation of the breadth described in the quote that opens this Preface.

Practice Set A, *Algebra and Arithmetic*, contains some simple problems for practicing your newly acquired MATLAB skills. Solutions are presented at the end of the book.

Chapter 4, *Beyond the Basics*, contains an explanation of some of the finer points that are essential for using MATLAB effectively.

Chapter 5, *MATLAB Graphics*, contains a more detailed look at many of the MATLAB commands for producing graphics.

Chapter 6, *MATLAB Programming*, introduces you to the programming features of MATLAB. This chapter is designed to be useful both to the novice programmer and to the experienced programmer.

Chapter 7, *Publishing and M-Books*, contains an overview of the word-processing and desktop-publishing features available in MATLAB 8.

Practice Set B, *Math, Graphics, and Programming*, gives you another chance to practice what you've just learned. As before, solutions are provided at the end of the book.

Chapter 8, *MuPAD*, describes the symbolic mathematics language MuPAD, which is embedded in the Symbolic Math Toolbox. MuPAD can be used as a stand-alone package for doing a large number of calculations, some of which cannot easily be done with MATLAB directly.

Chapter 9, *Simulink*, describes the MATLAB companion software Simulink, a graphically oriented package for modeling, simulating, and analyzing dynamical systems. Many of the calculations that can be done with MATLAB can be done equally well with Simulink.

Chapter 10, *GUIs*, contains an introduction to the construction and deployment of Graphical User Interfaces, that is *GUIs*, using MATLAB. This chapter is a little more advanced than most of the others.

Chapter 11, *Applications*, contains examples, from many different fields, of solutions of real-world problems using MATLAB, Simulink, and MuPAD.

Practice Set C, *Developing Your MATLAB Skills*, contains problems whose solutions use the methods and techniques you learned in Chapters 8–11.

Chapter 12, *Troubleshooting*, is the place to turn when anything goes wrong. Many common problems can be resolved by reading (and rereading) the advice in this chapter.

Next, we have *Solutions to the Practice Sets*, which contains solutions to all the problems from the three Practice Sets. The *Glossary* contains short descriptions (with examples) of many MATLAB commands and objects. Though it is not a complete reference, the Glossary is a handy guide to the most important features of MATLAB. Finally, there is a comprehensive *Index*.

## Conventions Used in This Book





We use distinct fonts to distinguish various entities. When new terms are first introduced, they are typeset in an *italic* font. Output from MATLAB is typeset in a monospaced typewriter font; commands that you type for interpretation by MATLAB are indicated by a **boldface** version of that font. These commands and responses are often displayed on separate lines as they would be in a MATLAB session, as in the following example:

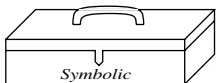
```
>> x = sqrt(2*pi + 1)
```

```
x =  
  2.6987
```

Some MATLAB windows have traditional menu bars near the top; in this book, selectable menu items are typeset in a **boldface** font. Submenu items are separated from menu items by a colon, as in **File:Save**. In MATLAB 8, many windows have a new layout featuring a *Toolstrip*, which has tabs that are organized into sections, each of which contains buttons and menus. Tab names in the Toolstrip are typeset in ALL CAPS; section names in SMALL CAPS; and buttons and menu items therein in **boldface**. We shall sometimes indicate a sequence of selections via colons, as in HOME:FILE:**New**. Labels such as the names of windows and (non-Toolstrip) buttons are quoted, in a “regular” font. File and folder names, as well as web addresses, are printed in a typewriter font. Finally, names of keys on your computer keyboard are set in a SMALL CAPS font.

We use seven special symbols throughout the book. Here they are, together with their meanings.

-  Paragraphs like this one contain cross-references to other parts of the book, or suggestions of where you can skip ahead to another chapter.
-  Paragraphs like this one contain important notes. Our favorite is “Save your work frequently.” Pay careful attention to these paragraphs.
-  Paragraphs like this one contain useful tips or point out features of interest in the surrounding landscape. You might not need to think carefully about them on a first reading, but they may draw your attention to some of the finer points of MATLAB if you go back to them later.
-  Chapters, sections, or problems starting with this symbol are a little more advanced than the rest of the book, and can be skipped on first reading if you wish.



Paragraphs like this discuss features of MATLAB’s Symbolic Math Toolbox, used for *symbolic* (as opposed to *numerical*) calculations. If you are not using the Symbolic Math Toolbox, you can skip these sections.



Paragraphs like this discuss features of Simulink. If you are not using Simulink, you can skip these sections.

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Paragraphs like this discuss features of the MuPAD program. If you are not using MuPAD, you can skip these sections.

Incidentally, if you are a student and you have purchased the MATLAB Student Version, then the Symbolic Math Toolbox, MuPAD, and Simulink are automatically included with your software, along with basic MATLAB and a few other toolboxes. We will mention some of these other toolboxes (the Image Processing Toolbox, the Optimization Toolbox, and the Statistics Toolbox) later in this book. With either the Professional Version or the Student Version of MATLAB, additional toolboxes are available if purchased separately.

## Additional Online Resources

The reader may find further resources to consult in conjunction with this book – including downloadable M-files used in the creation of some of the Solutions to the Practice Sets and the Applications in Chapter 10 – at the following site:

[www-math.umd.edu/schol/a-guide-to-matlab.html](http://www-math.umd.edu/schol/a-guide-to-matlab.html)

## About the Authors

We are mathematics professors at the University of Maryland, College Park. We have used MATLAB in our research, in our mathematics courses, for presentations and demonstrations, for production of graphics for books and for the Web, and even to help our kids do their homework. We hope you'll find MATLAB as useful as we do, and that this book will help you learn to use it quickly and effectively.

**Appreciation.** We are indebted to our former colleagues, Kevin Coombes, John Osborn, and Garrett Stuck, who contributed substantially to earlier editions of this book.

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Ronald L. Lipsman  
Jonathan M. Rosenberg

*College Park, Maryland  
August, 2013*