Preface

MATLAB$^{\textregistered}$[1] is an interactive system for numerical computation. Numerical analyst Cleve Moler wrote the initial Fortran version of MATLAB in the late 1970s as a teaching aid. It became popular for both teaching and research and evolved into a commercial software package written in C. For many years now, MATLAB has been widely used in universities and industry.

MATLAB has several advantages over more traditional means of numerical computing (e.g., writing Fortran or C programs and calling numerical libraries):

- It allows quick and easy coding in a very high-level language.

- Data structures require minimal attention; in particular, arrays need not be declared before first use.

- An interactive interface allows rapid experimentation and easy debugging.

- High-quality graphics and visualization facilities are available.

- MATLAB M-files are completely portable across a wide range of platforms.

- Toolboxes can be added to extend the system, giving, for example, specialized signal processing facilities and a symbolic manipulation capability.

- A wide range of user-contributed M-files is freely available on the Internet.

Furthermore, MATLAB is a modern programming language and problem solving environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent language for teaching and a powerful tool for research and practical problem solving. Being interpreted, MATLAB inevitably suffers some loss of efficiency compared with compiled languages, but built-in performance acceleration techniques reduce the inefficiencies and users have the possibility of linking to compiled Fortran or C code using MEX files.

This book has two purposes. First, it aims to give a lively introduction to the most popular features of MATLAB, covering all that most users will ever need to know. We assume no prior knowledge of MATLAB, but the reader is expected to be familiar with the basics of programming and with the use of the operating system under which MATLAB is being run. We describe how and why to use MATLAB functions but do not explain the mathematical theory and algorithms underlying them; instead, references are given to the appropriate literature.

The second purpose of the book is to provide a compact reference for all MATLAB users. The scope of MATLAB has grown dramatically as the package has been developed (see Table 0.1), and even experienced MATLAB users may be unaware of

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[1]MATLAB is a registered trademark of The MathWorks, Inc.

some of the functionality of the latest versions. Indeed the PDF documentation for
MATLAB runs to several thousand pages. Hence we believe that there is a need
for a manual that is wide-ranging yet concise. We hope that our approach of focus-
ing on the most important features of MATLAB, combined with the book's logical
organization and detailed index, will make *MATLAB Guide* a useful reference.

The book is intended to be used by students, researchers, and practitioners alike.
Our philosophy is to teach by giving informative examples rather than to treat every
function comprehensively. Full documentation is available in MATLAB's online help
and we pinpoint where to look for further details.

Our treatment includes many "hidden" or easily overlooked features of MATLAB
and we provide a wealth of useful tips, covering such topics as customizing graphics,
M-file style, code optimization, and debugging.

The main subjects omitted are object-oriented programming, Graphical User In-
terface (GUI) tools, and the publishing features. Every MATLAB user benefits,
perhaps unknowingly, from its object-oriented nature, but we think that the typical
user does not need to program in an object-oriented fashion. (For excellent examples
of the use of object orientation, see [10] and [95].) GUIs can be useful as front-ends
to MATLAB computations, but again, most users will not need to write them (for
an excellent example of a GUI, see `eigtool` [128]). The facility to publish an M-file
to HTML, XML, LATEX, etc. (new to Release 14) is best learned by using it and by
viewing the online documentation. Other areas not covered include MATLAB's Java
interface and some of the more advanced visualization features.

We have not included exercises; MATLAB is often taught in conjunction with
particular subjects, and exercises are best tailored to the context.

We have been careful to show complete, undoctored MATLAB output and to test
every piece of MATLAB code listed. The only editing we have done of output has
been to break overlong lines that continued past our right margin—in these cases we
have manually inserted the continuation periods "..." at the line break.

MATLAB runs on several operating systems and we concentrate on features com-
mon to all. We do not describe how to install or run MATLAB, or how to customize
it—the manuals, available in both printed and online form, should be consulted for
this system-specific information.

A Web page for the book can be found at

`http://www.siam.org/books/ot92`

It includes

- All the M-files used as examples in the book.

- Updates relating to material in the book.

- Links to various MATLAB-related Web resources.

What This Book Describes

This book describes MATLAB 7.01 (Release 14 with Service Pack 1), although most
of the examples work with at most minor modification in MATLAB 6 (Release 12)
and MATLAB 6.5 (Release 13). If you are not sure which version of MATLAB you
are using, type `ver` or `version` at the MATLAB prompt.

All the output shown was generated on a Pentium 4 machine running MATLAB
under Windows XP.

Table 0.1. *Versions of MATLAB.*

Year	Version	Notable features
1978	Classic MATLAB	Original Fortran version.
1984	MATLAB 1	Rewritten in C.
1985	MATLAB 2	30% more commands and functions, typeset documentation.
1987	MATLAB 3	Faster interpreter, color graphics, high-resolution graphics printing.
1992	MATLAB 4	Sparse matrices, animation, visualization, user interface controls, debugger, Handle Graphics®,* Microsoft Windows support.
1997	MATLAB 5	Profiler, object-oriented programming, multidimensional arrays, cell arrays, structures, more sparse linear algebra, new ordinary differential equation solvers, browser-based help.
2000	MATLAB 6 (R12)	MATLAB desktop including Help browser, matrix computations based on LAPACK with optimized BLAS, function handles, `eigs` interface to ARPACK, boundary value problem and partial differential equation solvers, graphics object transparency, Java support.
2002	MATLAB 6.5 (R13)	Performance acceleration, improved speed in core linear algebra functions for Pentium 4, more control in warning and error handling.
2004	MATLAB 7.0 (R14)	Mathematics on nondouble operands (single precision, integer), anonymous functions, nested functions, publishing an M-file to HTML, LaTeX, etc., enhanced plot annotation.

* Handle Graphics is a registered trademark of The MathWorks, Inc.

How This Book Is Organized

The book begins with a tutorial that provides a quick tour of MATLAB. The rest of
the book is independent of the tutorial, so the tutorial can be skipped—for example,
by readers already familiar with MATLAB.

The chapters are ordered so as to introduce topics in a logical fashion, with the
minimum of forward references. A principal aim was to cover M-files and graphics
as early as possible, subject to being able to provide meaningful examples. Later
chapters contain material that is more advanced or less likely to be needed by the
beginner.

Using the Book

Readers new to MATLAB should begin by working through the tutorial in Chapter 1.
The tutorial gives a fast-paced overview of MATLAB's capabilities, with all its topics
being covered in greater detail in subsequent chapters. Although it is designed to be
read sequentially, with most chapters building on material from earlier ones, the book
can be read in a nonsequential fashion by following cross-references and making use
of the index. It is difficult to do serious MATLAB computation without a knowledge
of arithmetic, matrices, the colon notation, operators, flow control, and M-files, so
Chapters 4–7 contain information essential for all users.

Appendix A lists our choice of the top 111 MATLAB functions—those that we
think every MATLAB user should know about. The beginner may like to tick off
these functions as they are learned, while the intermediate user can pick out for study
those functions with which they are not already familiar.

Experienced MATLAB users who are upgrading from versions earlier than version
7 should refer to Appendix B, which lists some of the main changes in recent releases.

What's New in the Second Edition

The first edition of this book described MATLAB 6 (Release 12). This second edition,
which is more than 30 percent longer, differs from the first in several respects.

1. Changes and new features introduced in Releases 13 and 14 of MATLAB are
   incorporated. Of these, the introduction of anonymous functions and nested
   functions has produced the most modifications to the existing material from
   the first edition.

2. Our continuing experience in using MATLAB for teaching and research has led
   to numerous improvements and additions—in particular, more examples.

3. A new chapter, "Case Studies" (Chapter 22), presents more substantial exam-
   ples of the use of MATLAB in a variety of problem areas.

4. A new appendix contains a list of the 111 most useful MATLAB functions.

5. Many sections contain new, or reorganized, material.

The main new MATLAB features described here are as follows (a page reference
is given for each feature, but see the index for full references):

- `logical` data type (p. 63);

- enhanced control of the `error` and `warning` functions (pp. 221, 223);

- `&&` and `||` operators with short-circuiting (p. 66);

- block commenting (p. 81);

- evaluation of passed functions without the use of `feval` (p. 144);

- `mlint` and related tools (p. 238);

- data types `single`, `int*`, `uint*` (p. 40);

- anonymous functions and nested functions (pp. 144, 151);

- new functions `linsolve` (p. 124), `ode15i` (fully implicit differential equations and differential-algebraic equations) (p. 193), `dde23` (delay differential equation solver) (p. 202), `pchip` (p. 162).

Acknowledgments

We are grateful to a number of people who offered helpful advice and comments during the preparation of the book.

For the first edition:

Penny Anderson, Christian Beardah, Tom Bryan, Brian Duffy, Cleve Moler, Damian Packer, Harikrishna Patel, Larry Shampine, Françoise Tisseur, Nick Trefethen, Jack Williams.

For the second edition:

Penny Anderson, Paolo Bientinesi, David Carlisle, Jacek Kierzenka, Cleve Moler, Jorge Moré, Jim Nagy, Larry Shampine.

It has been a pleasure working with the SIAM staff, namely with Sara Murphy, Linda Thiel, and Kelly Thomas for the second edition, and with Vickie Kearn, Michelle Montgomery, Deborah Poulson, Lois Sellers, Kelly Thomas, and Marianne Will for the first edition. For both editions we were delighted to work with our long-time copy editor Beth Gallagher.

For those of you that have not experienced MATLAB,
we would like to try to show you what everybody is excited about . . .
The best way to appreciate PC-MATLAB is, of course, to try it yourself.
— JOHN LITTLE and CLEVE B. MOLER, *A Preview of PC-MATLAB* (1985)

In teaching, writing and research,
there is no greater clarifier than
a well-chosen example.
— CHARLES F. VAN LOAN, *Using Examples to Build Computational Intuition* (1995)

A new era in scientific computing
has been ushered in by the development of MATLAB.
— LLOYD N. TREFETHEN, *Spectral Methods in MATLAB* (2000)