Preface

This is a book about computer programming that uses Maple™ for its concrete realization and so discusses both general concepts and technical details of Maple.[1] Current versions of Maple encompass most key aspects of modern programming languages: control structures, data types, numerics, graphics, spreadsheets, text processing, and object oriented programming, all of which are covered in this book. However, Maple is primarily a system for mathematical computation, which is also where my own interests mainly lie, so there is an emphasis on mathematical examples and a chapter devoted to algebraic programming.

Level

It is probably fair to describe this book as an "intermediate" course in Maple. It could be used to learn Maple from scratch, but the learning curve would be fairly steep for a reader who had no previous computing experience. Much of the material that I would expect to be covered in a first course is compressed into the first two chapters. By selecting between about half and two thirds of the material, it should be possible to use this as a textbook for a one-semester course on programming for mathematically oriented students pitched at some intermediate level, the precise level being determined by whether the easier material that comes earlier or the harder material that comes later is selected.

Maple coverage

In this book I focus on Maple 6 and throughout I use the new syntax introduced with Maple 6. I mention the major incompatibilities with recent earlier versions of Maple, but I do not (intentionally) use any obsolete syntax or facilities. My intention in writing this book was primarily to regard Maple 6 as the start of a new direction in Maple development and, as is probably inevitable, Maple 7 was announced while I was making the final revisions to

[1] Maple is a registered trademark of Waterloo Maple, Inc., 57 Erb St. W., Waterloo, Canada N2L 6C2, www.maplesoft.com.

the book. However, based on the announcement that I have seen, I anticipate that most, if not all, of this book will still apply to Maple 7, but I will make any necessary updates available via the web site for this book; see below.

I think it would be impossible to do justice to the whole of Maple in one book and I have not tried to do so. In particular, I mention very few of the many Maple packages and I hardly mention the "assume" facility. I have omitted in part or in total many advanced technical details that are covered in the *Maple 6 Programming Guide* [22] and the online help, such as Maple's internal data representations, advanced input and output facilities, very low and very high level graphics programming (I cover only the middle ground), and the new interface to external functions written in C.

Background

This book is based on about eight years' experience using and teaching Maple. It was developed from the lecture notes for a second Maple-based course for first-year mathematics students at Queen Mary, University of London, that I designed during the academic year 1993–94 and have taught ever since. It is primarily intended for joint mathematics and computer science students, and part of its aim is to provide an introduction to computer science for mathematics students.

The lecture notes on which this book is based were revised through at least four releases of Maple. However, this book is completely rewritten for Maple 6 and about half of the material is new.

A book developed from the first Maple-based course for first-year mathematics students at Queen Mary has just been published as *Experimental Mathematics with Maple* by Franco Vivaldi [27]. It provides a gentler introduction to Maple basics than I provide in Chapter 2 and an introduction to the mathematical background behind some of my examples, although it has more emphasis on mathematics and less on programming and does not use the new syntax that I use exclusively.

Structure of the book

This book falls into two parts: the first part comprises Chapters 1 to 6 and concerns basic Maple facilities that are accessible for interactive use; the second part comprises Chapters 7 to 15 and concerns programming in Maple. (Spreadsheets are difficult to classify; I regard them as an interactive programming facility and I have put them toward the end of the second part.) The book is mainly intended to be read sequentially. The chapters in the first part form pairs: Chapters 1 and 2 introduce Maple's user interfaces and basic syntax, Chapters 3 and 4 describe plotting in two and three dimensions, and Chapters 5 and 6 introduce numerical computing and numerical linear algebra. In the second part, Chapters 7 to 10 form a sequence that builds

up the techniques of computer programming using Maple and then Chapters 11 and 12 consolidate these programming techniques. The last three chapters are largely independent of each other and cover spreadsheets, text processing, and modules. The discussion of the use of Maple modules for object oriented programming and building packages and libraries is left until last because it involves probably the most sophisticated programming concepts and certainly the largest single body of code discussed in the book, which is too large to maintain comfortably within a worksheet.

Web site

There is a web site for this book at[2]

http://www.maths.qmw.ac.uk/~fjw/CwM/

Every chapter ends with a number of exercises, the incisiveness of many of which has been honed on my students over the years. The web site for the book provides model solutions in the form of Maple 6 worksheets, contact information, and supplementary material such as some of the more entertaining graphics developed in the book (two- and three-dimensional animations and a very simple example of "virtual reality", exported in standard web formats as explained in the text). It will provide any updates necessary for Maple 7 and it may also provide further discussion, examples, and corrections of errors — please let me know if you find any!

Production of the book

This book was written using various versions of Microsoft Windows. Maple is supposed to be largely independent of the platform on which it is run, but there are some inescapable differences, such as the number of buttons on a standard mouse: one on a Macintosh, two on Windows, and three on UNIX/Linux (which makes Windows a nice compromise). I have tried to deal with the "platform" issue in an even-handed way, but readers may still detect some Windows bias.

Each chapter of this book was written as a single Maple 6 worksheet consisting of text regions interleaved with execution groups, and containing all the necessary mathematical symbolism and diagrams. Only in the final stage of preparation was each worksheet exported as LaTeX [20] and then re-edited to correct and improve the formatting, but I have consciously tried to preserve the worksheet structure as closely as possible. Hence, all the Maple examples are essentially "live" and so should reflect how Maple 6 actually behaves. Before exporting each worksheet, I re-executed it from beginning to

[2] At some future date, the "qmw" in this URL may change to "qmul" to reflect the recent change of working title of the College to "Queen Mary, University of London".

end after restarting Maple, so each chapter is "WYSIWIG" (What You See Is What I Got) — more or less. At least, this defines the precise environment in which every Maple example was run and is the reason for occasional gratuitous Maple statements such as `unassign` and `restart`.

However, the LaTeX that Maple generates does not always correspond precisely with what is displayed in the worksheet. Hence, in particular, the Maple input examples generally do not show execution group delimiters, except in Chapter 1, where I reconstructed them by hand, and in one of the bitmap figures in Chapter 13 that I captured from the screen. I discuss execution group delimiters further near the end of Chapter 1.

The typography of the Maple output examples is an approximation to that used in the worksheets, whereas the typography of the mathematics that is part of the discussion is slightly different. In particular, Maple uses a roman font for *all* identifiers when they are applied as functions, whereas normal mathematical typography does this only for standard mathematical functions such as "log". Hence, in Maple output examples you will see typography such as $\mathrm{f}(x)$, whereas in the discussion I normally use $f(x)$.

A few Maple output examples introduce a label %1 for a common subexpression, which is defined immediately after it is used. This was not the case in the actual worksheets and probably occurred because I had to set a narrower page width for the LaTeX export than I was using for the worksheets. Also, quite a lot of minor editing was required to meet the requirements of publishing a book rather than worksheets, in particular the constraint of fitting the material into discrete pages having a fixed and fairly small size!

The example plots are shown as they appear in the worksheets; more precisely, in the form in which they were exported (automatically) by Maple as encapsulated PostScript files during export of the worksheets as LaTeX, which automatically converted all the colours to black. In the case of animations, Maple exports only the first frame, regardless of which frame is currently displayed in the worksheet. The first frame is often the least interesting, so I have cheated slightly and manually constructed and exported a more interesting frame in some cases. Nevertheless, to see actual animation, I encourage you to enter and run the code for yourself. (Or look at the animations on the web site.) A few figures are part of the discussion rather than Maple examples. Most of these were also produced using Maple, in which case the code is included (as extra examples, usually in an appendix) in each chapter in which such figures appear.

Chapter 13 is exceptional in that all the figures are bitmaps. The spreadsheets shown were all "captured" from the Maple worksheet display — I have sacrificed the typographical display quality of the tables in favour of showing how spreadsheets really appear in Maple. For variety, I constructed the two diagrams in this chapter as Microsoft Word Picture objects embedded in the Maple worksheet, which I later output directly from Word.

The worksheets contain a few non-ASCII characters (via Windows Character Map) and some embedded Microsoft Equation Editor objects to provide

mathematical notation that is not directly available in Maple. Care is required when typesetting the former in LaTeX and unfortunately Maple silently discards embedded objects when exporting as LaTeX so it was necessary to process non-ASCII characters and embedded objects by hand.

[A cautionary tale: When I was previewing a draft of this book, one figure appeared completely blank, for no obvious reason. It was Figure 13 in Chapter 13 and the day was May 13. Had it been a Friday I would have been suspicious, but in fact it was a Sunday! The following day I discovered that this and related problems were caused by the white space surrounding the bitmap figures, which needed to be clipped.]

Acknowledgements

For the final editing of the LaTeX version of this book I used GNU Emacs[3] extensively and several other GNU[4] utilities, many of them from the Cygwin[5] package. To produce the final PDF file I used MiKTeX[6] and GhostScript[7]. I thank the original developers of all this excellent free software and those who ported it to, and continue to develop it for, Windows.

I thank the following for helping to make this book possible: Marcelo Rebouças for inviting me to spend a sabbatical year from 1992 to 1993 at the Brazilian Center for Research in Physics (Centro Brasileiro de Pesquisas Físicas, CBPF), Rio de Janeiro, Brazil, where I developed and taught my first Maple course; my colleagues Franco Vivaldi and Leonard Soicher for many interesting discussions on Maple, computational mathematics, and algorithms; my colleague David Arrowsmith for professional support and encouragement; Waterloo Maple, Inc., for providing me with a personal copy of Maple 6 through their author support programme; and last but not least my family — Heather, Kathryn, and Madelyn — for allowing me the time to write this book.

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June 2001

[3] http://www.gnu.org/software/emacs/
[4] http://www.gnu.org/
[5] http://sources.redhat.com/cygwin/
[6] http://www.miktex.org/
[7] http://www.cs.wisc.edu/~ghost/