Preface

Modern computing tools like MAPLE (a symbolic computation package) and MATLAB®(a numeric and symbolic computation and visualization program) make it possible to use the techniques of scientific computing to solve realistic nontrivial problems in a classroom setting. These problems have been traditionally avoided, since the amount of work required to obtain a solution exceeded the classroom time available and the capabilities of the students. Therefore, simplified and linearized models are often used. This situation has changed, and students can be taught with real-life problems which can be solved by the powerful software tools available. This book is a collection of interesting problems which illustrate some solution techniques in Scientific Computing. The solution technique for each problem is discussed and demonstrated through the use of either MAPLE or MATLAB. The problems are presented in a way such that a reader can easily extend the techniques to even more difficult problems.

This book is intended for students of engineering and scientific computing. It is not an introduction to MAPLE and MATLAB. Instead, it teaches problem solving techniques through the use of examples, which are difficult real-life problems. Please review the MAPLE and MATLAB documentation for questions on how to use the software.

All figures in the book were created either by using graphic commands of MAPLE and MATLAB or by direct use of *xfig* on a SUN workstation. Occasionally changes were made by Dr. S. Bartoň in the postscript files to improve the visual quality of the figures. These changes include different font sizes, line types, line thicknesses, as well as additional comments and labels.

This book was written as a collaboration between three institutes:

- the Department of Theoretical Physics and Astrophysics of Masaryk University, Brno, Czech Republic,

- the Institute of Physics of the University of Agriculture and Forestry, Brno, Czech Republic, and

- the Institute of Scientific Computing ETH, Zürich, Switzerland.

The authors are indebted to the Swiss National Science Foundation which stimulated this collaboration through a grant from the "Oststaaten-Soforthilfeprogramm". An additional grant from the ETH "Sonderprogramm Ostkontakte" and support from the Computer Science Department of ETH Zürich made it possible for Dr. S. Bartoň to spend a year in Zürich. He was the communication link between the two groups of authors and without him, the book would not have been produced on time. We would also like to thank Dr. L. Badoux, Austauschdienst ETH, and Prof. C.A. Zehnder, chairman of the Computer Science Department, for their interest and support.

Making our Swiss- and Czech-English understandable and correct was a major problem in producing this book. This was accomplished through an internal refereeing and proofreading process which greatly improved the quality of all articles. We had great help from Dr. Kevin Gates, Martha Gonnet, Michael Oettli, Prof. S. Leon, Prof. T. Casavant and Prof. B. Gragg during this process. We thank them all for their efforts to improve our language.

Dr. U. von Matt wrote the LaTeX style file to generate the layout of our book in order to meet the requirements of the publisher. We are all very thankful for his excellent work.

D. Gruntz, our MAPLE expert, gave valuable comments to all the authors and greatly improved the quality of the programs. We wish to thank him for his assistance.

The programs were written using MAPLE V Release 2 and MATLAB 4.1. For MAPLE output we used the ASCII interface instead of the nicer XMAPLE environment. This way it was easier to incorporate MAPLE output in the book. The programs are available in machine readable form. We are thankful to The MathWorks for helping us to distribute the software.

Zürich, September 13, 1993 Walter Gander, Jiří Hřebíček

Preface to the second edition

The first edition of this book has been very well received by the community, and this has made it necessary to write a second edition within one year. We added the new chapters 20 and 21 and we expanded chapters 15 and 17. Some typographical errors were corrected, and we also rephrased some text. By doing so we hope to have improved our English language.

All programs were adapted to the newest versions of the software i.e. to MAPLE V Release 3 and to MATLAB Version v4. In order to simplify the production of the book we again chose the *pretty print* output mode for the MAPLE output.

We dedicate the second edition to our late colleague František Klvaňa. We all mourn for our friend, a lovely, friendly, modest person and a great scientist.

Druhé vydání je věnováno památce našeho zesnulého kolegy Františka Klvaňi. Všichni vzpomínáme na našeho drahého přítele, milého a skromného člověka a velkého vědce.

Zürich, October 7, 1994 Walter Gander, Jiří Hřebíček

Preface to the third edition

In the present edition the book has been enlarged by six new chapters (Chapters 22–27). Some of the previous chapters were revised: a new way to solve a system of differential equations was added to Chapter 1. Chapter 17 on free metal compression was completely rewritten. With the new approach, the compression of more general bodies can be simulated.

The index has been considerably enlarged and split into three parts, two of them containing all MAPLE and MATLAB commands used in this book. We are indebted to Rolf Strebel for this work.

All chapters have been adapted to the newest versions of MAPLE (Version 5 Release 4) and MATLAB 5. The calculations for MAPLE were done on Unix workstations by Standa Bartoň and Rolf Strebel, who also produced the worksheets. Notice that the order of the terms in sums and products and the order of the elements in sets is unspecified and may change from session to session. When the MAPLE commands are re-executed, one may get results in a different representation than those printed in the book. For example, the solution of a set of equations may depend on different free parameters. Commands which depend on the order of previous results (like accesses to sets and expression sequences) may have to be adjusted accordingly. Since we have re-executed the MAPLE examples with Release 4, some statements have changed compared to the previous editions of this book.

All MATLAB computations were performed on a PC, equipped with an Intel Pentium Pro Processor running under Windows NT 4.0 at 200 Mhz using MATLAB 5.0. We are indebted to Leonhard Jaschke for taking care of these test runs. MATLAB 5 offers new M-files for the integration of differential equations. While in the older versions one had to specify an interval for the independent variable, there are now new possibilities to stop the integration process. We have made use of this new feature and simplified our codes.

A criticism by some reviewers that the ASCII output of MAPLE does not look nice has been taken into consideration. We have transformed all the formulas using the MAPLE `latex`-command into LaTeX. We thank Erwin Achermann who checked and adapted the layout.

The two systems MAPLE and MATLAB seem to come closer to each other. There is the Symbolic Math Toolbox for MATLAB which can be used to call MAPLE from a MATLAB program. Also, there are plans that in the near future a similar mechanism will be available on the other side. We have not made use of the Symbolic Math Toolbox, mainly because we do want to use both systems equivalently and complementarily.

The MATLAB and MAPLE programs (and worksheets) are available via anonymous ftp from `ftp.inf.ethz.ch`[1]

We dedicate this edition to one of our co-authors—the one with the highest seniority—Professor Heinz Schilt, the expert in Switzerland for computing and constructing sun dials with typical Swiss precision.

Zürich, March 18, 1997 Walter Gander, Jiří Hřebíček

Preface to the second printing of the third edition

After the third edition was sold out the authors decided to have a second printing of the third edition with updated programs. All programs have been adapted to the newest versions : MAPLE 7 and MATLAB Version 6.1.0.450 Release 12.1. The computations were performed by Stanislav Bartoň with the help of Dominik Gruntz and Rolf Strebel on SUN workstations at ETH. Stanislav discovered a bug in the `fsolve`-function of MAPLE 7. The following command is necessary in order to overcome the bug

```
> `fsolve/EvalAtx` := subs( subs=((x,y)->eval(y,x)),
>  eval(`fsolve/EvalAtx`));
```

We thank Maplesoft for providing this workaround to that problem (see Chapter 7). This saved us from having to add a home made zerofinder to solve the equation in Section 7.4.4. Waterloo Maple has assured us that this bug will be fixed in an upcoming release of MAPLE.

[1]URL: `ftp://ftp.inf.ethz.ch/pub/software/SolvingProblems/ed3/`

Stanislav Bartoň would like to thank Petr Byron, director of HUMUSOFT, Prague (`www.humusoft.cz`), for providing him free access to the newest release of MATLAB.

Zürich, September 3, 2001, Walter Gander, Jiří Hřebíček

Preface to the forth edition

This is now the forth edition and we are happy to celebrate the 10th anniversary of this book! It has been enlarged by four new chapters (Chapters 28–31). Some of the previous chapters were revised using new possibilities offered by MAPLE and MATLAB. We would like to thank Stanislav Bartoň and Jan Pešl for testing and adapting all the programs to the newest versions of the software: MAPLE 9 and MATLAB 6.5 Release 13. Stanislav Bartoň would like to thank Petr Byron for again providing him free access to the newest release of MATLAB. No bugs were found in the new versions – the function `fsolve` of MAPLE has been fixed and makes no troubles anymore in Chapter 7.

We have decided to create a web page for the book. The address is

`www.SolvingProblems.inf.ethz.ch`

All MAPLE and MATLAB programs are available through this web page. The web has become a overwhelming source of information for each one of us. We felt that it would be useful to list some important and interesting web pages related to MAPLE and MATLAB. This information can be found in the appendix. When we started this book 10 years ago, there was not much similar material around. The world has definitely changed and one can find many interesting solved problems in scientific computing in cyber space. We are glad to have participated as pioneers in this development.

Zürich, December 17, 2003, Walter Gander, Jiří Hřebíček