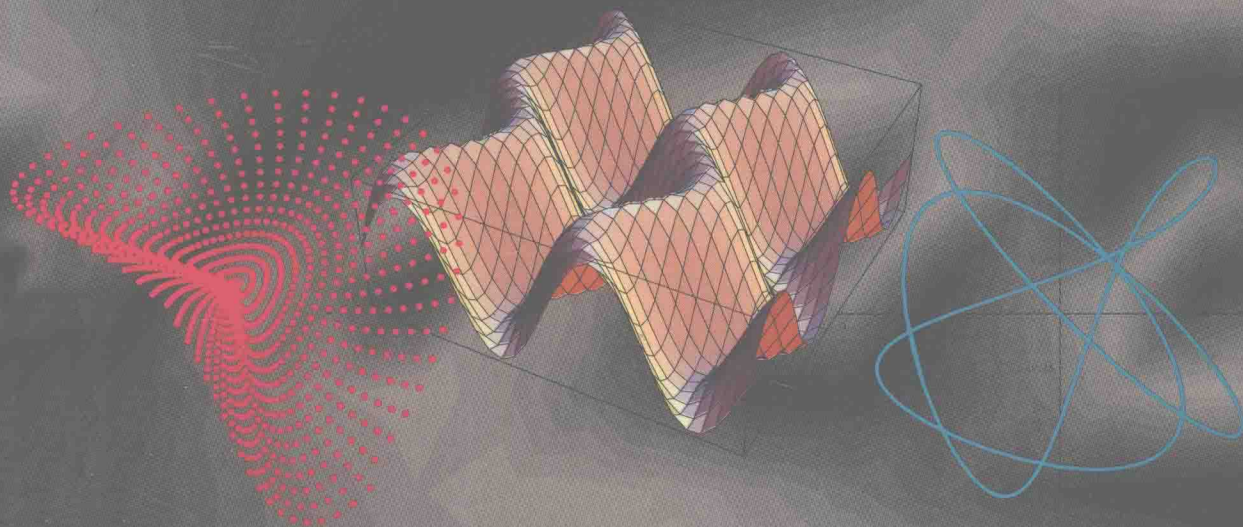# The

BEGINNER'S

GUIDE

TO

Mathematica. 2

VERSION

Theodore W. Gray and Jerry Glynn

The Beginner's Guide to *Mathematica*®

Version 2

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The Beginner's Guide to *Mathematica*®

Version 2

Preface

This book is both a tutorial and a reference book. To use it as a tutorial, start at the beginning and read the chapters in order. You will get a good idea of what *Mathematica* does, and will find things explained in a sensible order. To use it as a reference, scan the table of contents to find the question you want answered.

Although this book will get you started using *Mathematica*, it is not a complete reference work. You can't use *Mathematica* effectively without a copy of *Mathematica, a System for Doing Mathematics by Computer*, second edition, by S. Wolfram (see the references section for more information).

We are indebted to several people for help with the book.

Scott May of Wolfram Research suggested the chapter "Why didn't it work when I tried to load a package?", based on the hundreds of people who have had this problem and called him to get it solved. He also suggested the discussion of plotting 3D points as a surface in "How do I plot a list of points?".

Stephen Wolfram made many helpful comments, and suggested the plug for **Trace** in "How do I program in *Mathematica*?".

The following people read manuscripts, and made helpful comments: Henry Edwards, Eva Gray, John Gray, Jerry Keiper, Doug Stein, and Dave Withoff.

David Eisenman edited the entire book, and made it better.

Allan Wylde from Addison-Wesley first proposed that we write the book. We wish him the best of luck with his new publishing endeavors. Peter Gordon, who took over responsibility for the book at Addison-Wesley, encouraged us to increase the book's scope (and quality). Helen Goldstein, Nev Hanke, and several anonymous copyeditors helped tremendously.

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Chapter 1
What computer should I use?

This chapter is not about what kind of computer you *could* use to run *Mathematica*. It is about what kind of computer you *should* use. If you plan to buy a computer to run *Mathematica*, you can use this chapter as a buying guide. If you're not planning to buy a computer soon, you can use this chapter as a guide to what kind of computer to borrow, use in a lab, rent, or use as a criterion for choosing friends.

There are four computer worlds: Macintosh, NeXT, MS-DOS, and UNIX. These worlds are very different from each other and do not communicate with each other (except for slight kibitzing between the NeXT and UNIX worlds). When you buy a computer, you are not just buying a computer; you are buying into one of these worlds.

Understand that there are real differences between these worlds. If you buy a Macintosh, you will pay more than you want to. If you buy an MS-DOS computer, you will be limited in the quality of application software you can buy. If you buy a NeXT, you will not be able to find many people around you to help if you have problems. If you buy a UNIX computer, you will have to learn a lot of technical details or employ someone who knows these details.

To make an analogy, an MS-DOS computer is like a 1973 Dodge. A bit creaky, not very comfortable, but as the used car ads say, it runs good. A NeXT computer is like a great deal on a brand new Lamborghini: fast, slick, but hard to get serviced. A UNIX computer is like a kit car: You had better be pretty committed before buying one. A Macintosh is like a

Toyota Camry: good, solid quality, but a little more expensive than it should be.

For many people, the only computer that makes sense is the Macintosh. NeXT and UNIX computers do not have the range of application software (spreadsheets, wordprocessors, desktop publishing software, etc.) that most people need. MS-DOS computers have little software that is not either hard to use or poorly designed. Microsoft Windows is ugly, and too slow except on the fastest 80386- and 80486-based computers, which cost as much as Macintoshes. (The reader may suspect a slight bias in the treatment of MS-DOS computers by at least one of the authors. The reader, in this case, would be correct.)

The Macintosh II*si* is a good choice for many people. The II*lc* is relatively inexpensive and can be upgraded to run *Mathematica* satisfactorily, but be warned that it is not able to use the virtual memory features of System 7 and is therefore ultimately limited (for more information about virtual memory, see Chapter 2, "How do I make my computer work best with *Mathematica*?"). The Macintosh Plus, Classic, and SE are poor choices because they can hold at most 4MB of memory, which is not enough to run *Mathematica* well. The old Macintosh Portable and the new PowerBook 100 are OK, but suffer from the same restrictions as the II*lc*.

The SE-30, Classic II, PowerBook 140, and PowerBook 170 are all good choices. The Classic II is a particularly inexpensive model that supports virtual memory and can run *Mathematica* well. On the high end, the II*fx* and Quadra series are good choices, although they are expensive. Of course, there are always new models of Macintosh coming out, so don't limit yourself to the models discussed here. Any Macintosh capable of supporting virtual memory is OK, and any other Macintosh that supports at least 8MB of RAM is also OK, but not as good as one that supports virtual memory.

The NeXT computer is also a good choice for many people. It is a very exciting computer and is likely to be setting trends for many years to come. The NeXT is a very fast, very powerful computer with a high-

quality user interface at a good price (a basic NeXTStation system costs less than a good Macintosh system and runs several times faster). A small number of wordprocessors, spreadsheets, and other software packages are available currently, but not enough to satisfy an aggressive user. More software is likely to be available in the future, and that software is likely to be of a quality comparable to Macintosh software.

UNIX computers are usually a good choice only for computer-oriented people. They are difficult to maintain, requiring extensive familiarity with the UNIX operating system. Sun Microsystems computers come closest to being "end user" computers but are still rather difficult to set up and use. On the other hand, it is possible to buy an incredible amount of raw computer power for very little money in the UNIX market. UNIX computers are usually best used as "compute servers" in departmental or lab settings. If you don't know what that means, you don't want one.

Versions of *Mathematica* are available for almost any computer capable of running it, so that is usually not a factor in choosing your computer. (Be sure to check availability before buying, of course.)

Chapter 2
How do I make my computer work best with *Mathematica*?

Mathematica is a very big program. It is by far the biggest program most people ever run on their computers. Because of this, you may encounter problems with *Mathematica* that are not likely to occur with other programs.

To run *Mathematica*, you must have enough memory and enough disk space. Otherwise, *Mathematica* will not run at all, or it will run very slowly or crash frequently. How much memory is enough? That depends on the brand of computer you are using.

If your computer does not have enough memory or disk space, you will need to upgrade it before using *Mathematica*. As a general rule, it is not a good idea to buy either memory or hard disks from the manufacturer of your computer. You can get both *much* cheaper from specialists who advertise in the backs of computer magazines. (Note that it is usually not necessary to worry about quality. Both memory chips and hard disks are manufactured by only a small number of large companies, all of whom are quite reputable. Small dealers sell exactly the same chips and disks as anyone else; they just have a much lower markup. Most offer a one-year warranty, and in any case the chance of a memory chip or hard disk failing is relatively small: They are pretested and reliable.)

Macintosh

The absolute minimum is 4MB of memory and about 5MB of disk space. If you have only 4MB of memory, you can load *Mathematica* and you can do a few simple calculations, but you can't, for example, do any definite integrals. This is not a practical configuration. In addition, you can't use MultiFinder together with *Mathematica* with only 4MB of memory.

If you have 5MB of memory, you can do quite a bit more. If you have 8MB (the minimum recommended amount) you can do a lot, even with Multi-Finder running.

If you have installed Macintosh System 7, things are a little different. System 7 includes a feature, called virtual memory, that allows you to use space on your hard disk as if it were additional main memory (RAM). Since hard disk space is a lot cheaper than RAM, this allows you to expand your memory cheaply. For example, if you have an 80MB hard disk, you could allot 20MB on the disk for virtual memory. Even if your computer has only a few megabytes of memory, it will act as if it had 20MB of memory.

If you have a Macintosh II, II*cx*, II*ci*, II*si*, II*fx*, SE-30, Classic II, PowerBook 140, PowerBook 170, or Quadra, or any other Macintosh with a 68020, 68030, or 68040 main processor, you can use virtual memory. (Some Macintosh II models require a relatively inexpensive PMMU chip upgrade before they can use virtual memory.) It is reasonable to have as little as 4MB of actual main memory with 8 or more megabytes of virtual memory. It is not at all unreasonable to give *Mathematica* 20 or 30MB of virtual memory in some cases.

Your Macintosh user's manual and the System 7 user's manual explain how to change the amount of virtual memory and the amount allotted to *Mathematica*.

If you have a Macintosh Plus, SE, Classic, LC, PowerBook 100, or any other Mac with a 68000 main processor, you can't use the virtual memory features in System 7. Since System 7 includes only MultiFinder (not Finder),

this means that you *cannot* run *Mathematica* and System 7 at all on a machine with less than 8MB that does not support virtual memory. It *is* reasonable to run *Mathematica* and System 7 with 8MB.

NeXT

Special Note! *Mathematica* is *not* compatible with NeXT operating system version 2.0. To run *Mathematica*, you *must* upgrade your NeXT to system 2.1. This upgrade is available free or for a small fee from NeXT or your local NeXT reseller.

Any NeXT computer is able to run *Mathematica*, but the smallest configurations run too slowly. Because NeXT computers use virtual memory, the amount of main memory (RAM) does not affect what you *can* do, only how fast it works. A NeXT with the minimum configuration of 8MB will run *Mathematica*, but too slowly. It is *not* recommended to run *Mathematica* with only 8MB. A NeXTStation or NeXTCube with 14MB or a NeXTStation Color with 20MB is reasonable. A NeXTDimension requires at least 16MB on the main board and 16MB on the display board to give acceptable performance. (If you want to have a lot of windows open at the same time, you need more memory on the display board: 32MB seems to be enough for most people.)

NeXTStation and NeXTCube memory is the same as Macintosh memory: Any 80ns or 100ns Macintosh memory modules will work in a NeXT. (Note that Macintosh IIfx memory is different and doesn't work in anything else.) This means you can buy memory inexpensively from Macintosh memory dealers. NeXTStation Color and NeXTDimension display board memory is different and harder to get: You may have to buy it from NeXT.

Because of the way virtual memory works on the NeXT, the more memory you use, the more disk space it takes up. It is, in fact, possible to completely fill up your hard disk just by running a big calculation in *Mathematica*. This can have serious consequences: You will not be able to save files, for example, and it is even possible to get the disk into a situation where it is no longer possible to start up the computer.

If your NeXT has only a 100MB or 200MB hard disk, you need to pay attention to disk space. **Don't start** *Mathematica* **unless at least 20MB of disk space is free.** After running for a few days, rebooting your NeXT will shrink the virtual memory file to its minimal size; this usually frees up some disk space. You might consider deleting things you don't need, or getting a bigger hard disk.

The NeXT has a SCSI bus for connecting external disks. This means that hard disks are more or less interchangeable between Macintosh, NeXT, and most UNIX computers. Disks that work on one usually also work on the other (although the formatting is completely different, so you can't transfer data this way). This means you can buy inexpensive disks from small dealers. Because there are certain potential incompatibilities, be sure to ask for a NeXT-compatible (or UNIX-compatible) disk.

MS-DOS

Mathematica runs only on 80386, 80486, or newer MS-DOS computers. You will need a numeric coprocessor, and a hard disk. A VGA color screen is also strongly recommended.

The "DOS" version of *Mathematica* runs as a command-line program under the DOS shell. It uses virtual memory, so, in theory, the amount of main memory (RAM) you have does not affect what you can do, only how long it takes. As a practical matter, you need at least 4MB of RAM; if you have less, *Mathematica* will run too slowly to be useful. The DOS version will run comfortably with 6MB.

The virtual memory system used with the DOS version automatically allocates a virtual memory swap file when it is started up, and deletes it when the program exits. The swap file grows bigger as you use more memory. You need to have at least 14MB of free disk space before starting *Mathematica*, to allow room for the swap file to grow. If you intend to do any large calculations, allow more disk space. If the swap file grows to fill your whole disk, you will have trouble!

The swap file works most efficiently if it can be allocated in one (or a small number) of contiguous blocks on your disk. Because of this, it is a good idea to run one of the many disk "optimization" utilities from time to time (the relevant option is often called something like "defragment free space"). These utilities shift the contents of the disk to bring all the free space together in one area.

Microsoft Windows

Mathematica runs only on 80386, 80486, or newer MS-DOS computers. You will need a numeric coprocessor, and a hard disk. A VGA color screen is also strongly recommended.

The "Windows" version of *Mathematica* runs under Microsoft Windows 3.0 (or later versions), and includes the Notebook front end. The Windows version requires somewhat more memory than the "DOS" version.

The Windows version uses Windows virtual memory, so, in theory, the amount of main memory (RAM) you have does not affect what you can do, only how long it takes. However, if you have less than about 6MB of RAM, *Mathematica* will run too slowly to be useful. The Windows version will run comfortably with about 16MB.

You need to allow for at least 16MB of disk space for virtual memory. There are two different ways to do this. You can allocate a "permanent" swap file, which cannot grow, or you can use a "temporary" swap file, which grows bigger as you use more memory, and is deleted when you exit Windows.

The permanent swap file is more efficient (faster) than the temporary one. The main disadvantage is that if you want to use more memory than you initially allocated, you have to go through a relatively lengthy process to reallocate a new, larger, permanent swap file. Also, the disk space allotted to the swap file is not available for other uses, even when you are not using Windows. In addition, certain disks have driver software that is not able to support a permanent swap file.

A temporary swap file can be almost as efficient as a permanent one, provided you run a disk optimization program periodically (the relevant option is often called something like "defragment free space"). The main danger of using a temporary swap file is that it may grow to use up all your free disk space, at which point you will have trouble!

Mathematica users are recommended to upgrade to Windows 3.1 when it becomes available.

UNIX

UNIX computers vary immensely in the way they handle memory and disk space. It is difficult to generalize, but 8MB of main memory and 20MB to 30MB of virtual memory is probably the minimum you want. The installation instructions for *Mathematica* on each type of computer will list the minimum requirements. Generally you will need more than these minimums to run *Mathematica* reasonably well: The minimums are minimal, not typical, requirements.