

1 INTRODUCTION

Sections

- 1.1 A Beginning
- 1.2 Maple
- 1.3 Using Maple
- 1.4 Maple Environment
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- Key Terms

Objectives

After reading this chapter, you should be able to:

- Relate engineering and science to problem solving
- Compare mathematics and computers to tools
- Understand how Maple operates
- Explain the problem-solving process
- Describe the notations employed in this text
- Identify elements of the Maple workspace
- Access on-line help
- Create, open, save, and print worksheets

1.1 A Beginning

Have you asked, yet, why should you learn Maple? Perhaps a teacher or colleague might tell you, “Because Maple is a great program that solves hard problems,” or, perhaps, “Because you have to.” Yes, your teachers probably expect a measure of faith that you believe in Maple. Throughout this text, I hope to demonstrate Maple’s power and elegance. For now, read through this chapter to get a “taste” for Maple.

1.1.1 Problems

Maple is about problem solving. What distinguishes *engineering* and *science* problems from other problems? Certainly not all tasks require an engineer or scientist! Loosely defined, scientists *develop* theoretical concepts of the physical world, and engineers then *apply* these theories to create physical systems, devices like light-bulbs and toenail clippers. Yes, physics helps to keep our nails trimmed!

1.1.2 Tools

How do people construct devices? Usually, with *tools*. Tools assist with thinking, analysis, testing, and making things that solve problems. Tools include physical *devices* and abstract *methods*. Physical tools, like machinery, extend human physical capabilities. Abstract tools, like algorithms, enhance problem solving.

1.1.3 Modeling

Models are tools that analyze and predict physical behaviors. Science and engineering models often combine features of physical and abstract tools. Using algorithms and equations, for

example, manufactures often build prototypes before mass-marketing goods for testing after designing. Well-devised models reasonably and efficiently predict accurate behaviors. The abstract model provides a design, whereas the prototype provides a reality-check to see if the device really works.

1.1.4 Experimentation

Experimentation yields good models. For instance, consider a building and the idealized model of it, as shown in Figure 1-1. Over many years, laboratory testing and theoretical development have provided engineers with idealized, mathematical models that assist in structural design. Continued testing between idealized and actual behaviors improves both understanding and development of better models.‡

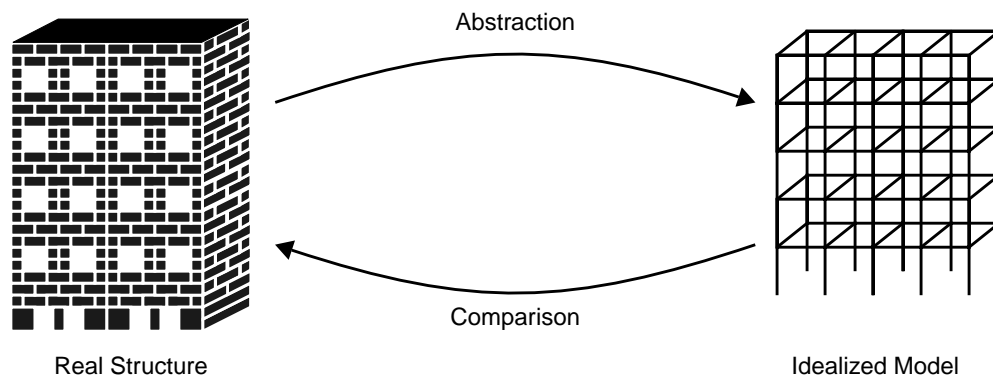


Figure 1-1 Basic Modeling

‡. Can buildings have prototypes, like other mass-marketed goods? Imagine having to destroy buildings in succession until building a one that won't topple! Here, robust abstract models are crucial.

1.1.5 Mathematics

Mathematics provides abstract models. Scientists and engineers represent physical processes with equations. Mathematical models usually involve a combination of symbolic and numerical features:

- A *symbolic model* is *qualitative*, because it represents a general equation. For instance, the equation $y = mx + b$ represents a symbolic mathematical model, where the letters y , m , x , and b represent different numerical values.
- A *numerical model* is *quantitative* because it substitutes specific numerical values for the terms in a symbolic model. For instance, using values $m = 1$, $x = 2$ and $b = 3$, produces a quantitative result of $y = 5$.

1.1.6 Computers

Tools, such as *computers*, assist in complex mathematical analysis and other burdensome tasks. Hardware and software make up the “body” and “mind” of a computer, respectively. Hardware consists of the physical devices. Software provides the “intelligence” for computations and communication. So, what makes software a tool? Software helps people solve problems as with any other tool.‡

‡. Application software implements mathematical models for analysis and design. Understand, however, a program’s assumptions and limitations, as you would with any model! Always check your output with simpler, “textbook” models.

1.2 Maple

Maple provides a powerful software tool used primarily for symbolic analysis, but has presently strengthened its numerical abilities. This section provides a brief overview of Maple’s capabilities and structure.

1.2.1 Computer Algebra System

Maple implements a *computer algebra system* (CAS) for symbolic mathematics. A CAS provides commands for manipulating and deriving symbolic equations from other equations. A software “engine” inside a CAS uses *analytical methods* to find exact answers, often in symbolic form. Maple employs numerical methods as well, and now implements many numerical routines with NAG (Numerical Algorithms Group).

1.2.2 History of Maple

Computer-based, symbolic analysis was introduced in the late 1960’s. In case you’re curious where the name *Waterloo Maple* came from, Symbolic Computation Group at the University of Waterloo in Canada started Maple as a project in 1980. Eventually, Waterloo Maple, Inc. commercially released Maple. Maple has remained popular in both academic and commercial environments.

1.2.3 Why Maple?

Maple is very useful for a number of reasons. Maple does the following:

- performs symbolic and numerical analysis for a wide variety of tasks.
- contains a rich library of over 2500 functions.
- helps you construct customized programs by using Maple commands.
- provides access to other popular software packages.

1.2.4 How Does Maple Work?

The *kernel*, *library*, and an *interface* make up the structure of Maple, as shown in Figure 1-2:

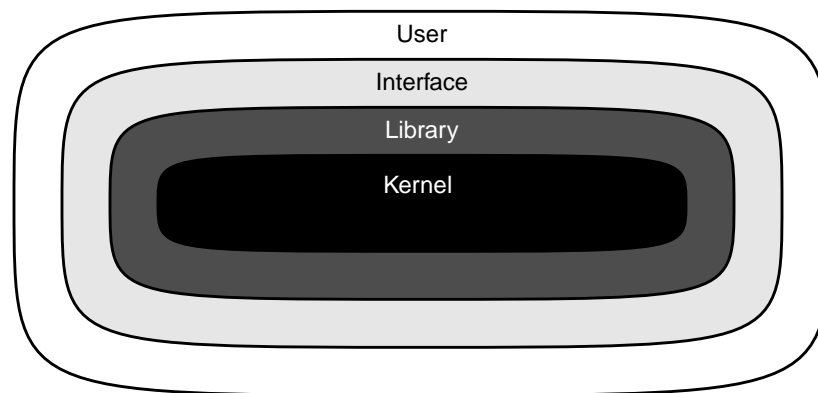


Figure 1-2 Maple Structure

- **Kernel:** About 10% of Maple functions make up the Maple kernel, the core command group. These commands interpret and process input, evaluate numerical quantities, and manage memory. Maple provides both *shared* and *parallel* kernels, as discussed in Chapter 3.
- **Library:** About 90% of Maple's commands called *functions* are written in Maple code and kernel operations. For example, entering `sin(0)` causes Maple to evaluate the value of the function `sin(0)`. Functions automatically load when starting Maple. Some functions

are stored in library packages which require special loading procedures, as discussed in Appendix D.

- **Interface:** The user communicates with Maple through the interface. Maple interprets commands and evaluates the desired procedures. Although Maple provides a text-based interface, this text focuses on the **graphical user interface** (GUI) version of Maple which uses menus and windows. These interfaces are discussed in the next chapter.
- *User:* That's you!

1.3 Using Maple

This text covers the version of Maple called *Maple 6*. A few important distinctions with the previous version, *Vr5*, are noted throughout the text. Beware that not all computer platforms support these same features.

1.3.1 Problem-Solving Methodology

Each chapter in this book applies Maple for solving a variety of problems. As you work through these problems, follow a general problem-solving methodology, as illustrated in Figure 1-3. In general, break problems down into smaller, more manageable subproblems. Also, when steps fail, go back to previous steps and iterate for better solutions. You might wish to think of this process as a more refined “trial-and-error” system.

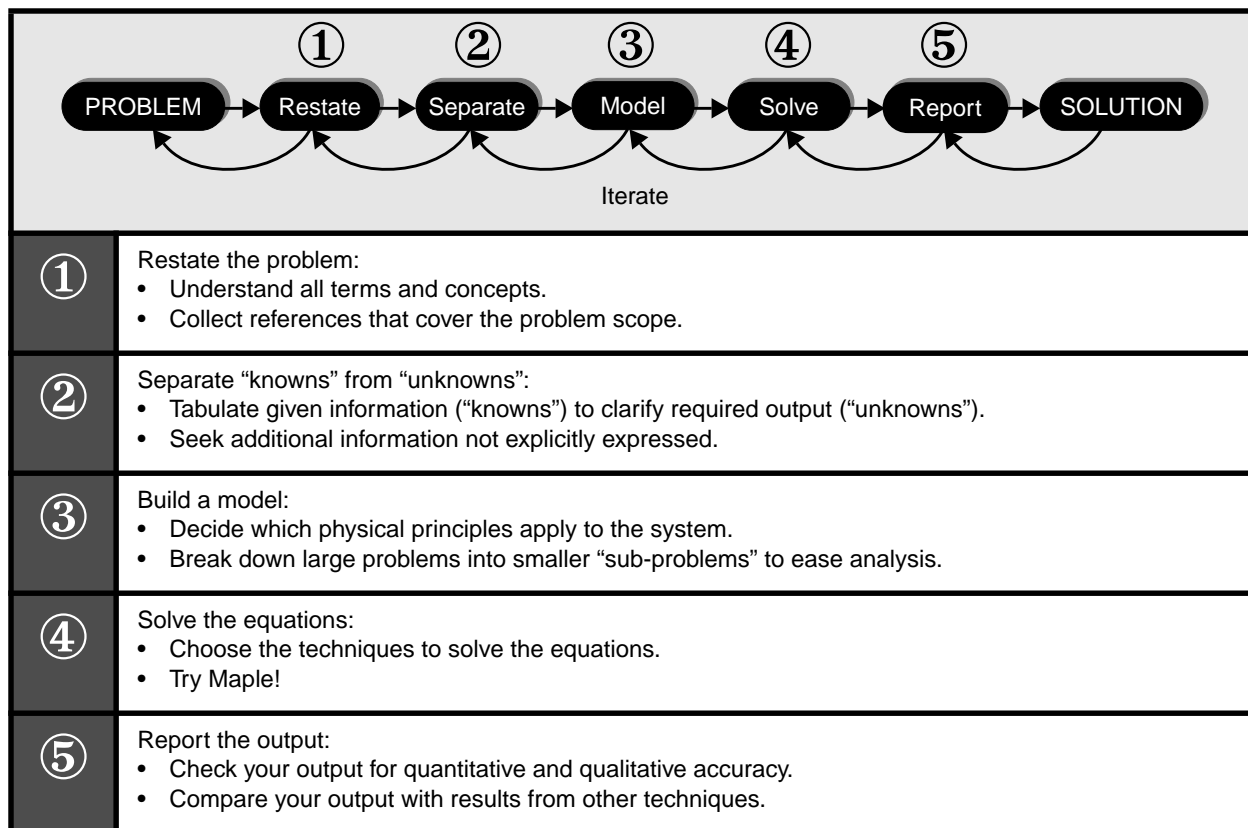


Figure 1-3 Problem-Solving Methodology

1.3.2 Notation

Before attempting anything, thoroughly review the notation in Table 1-1. Computer manuals and textbooks are typically awash with such notation. I suggest you tab that page because you’ll need it while getting used to this text.

1.4 Maple Environment

This section provides a brief overview of Maple’s GUI environment. You should try all *Practice!* problems after reading the following material.

Table 1-1 Notation

Notation	Description
Key Terms	These <i>terms</i> involve important concepts and are shown in boldface italics. There is a list of key terms at the end of each chapter.
Input	input and commands are shown in boldface, fixed-width font. For example, you would enter the mathematical expression $\sin(x)$ as sin(x) .
Arguments	Many Maple commands take <i>arguments</i> , which are values that can vary. Arguments are shown in boldface italicized fixed-width font. Never type the literal word “ argument ”! Always type the value of “ argument ” instead.
<i>Output</i> and <i>Equations</i>	GUI Maple reports most <i>output</i> in italics. Why? Many textbooks show mathematical expressions and equations in italics. For example, entering sin(x) in Maple would produce the output $\sin(x)$.
Computer	When you make a mistake, Maple sometimes produces output in fixed-width font called an error message to report your blunder.
Text	You may also add plain text in Maple. Although Maple allows different fonts, this book shows plain text in this font.
<i>commentary</i>	My <i>comments</i> are shown in this small, italic font. Never enter these comments into Maple commands!
	↵ Press the Enter or Return key on your keyboard.
<u>M</u> enu1→ <u>M</u> enu2	Select <u>M</u> enu items by pointing and clicking the left mouse button. For instance, the sequence <u>E</u> dit→ <u>E</u> xecute→ <u>W</u> orksheet instructs you to select <u>E</u> dit. You may now select from the submenu. Point your mouse on <u>E</u> xecute. Finally, click on <u>W</u> orksheet. You can also press the Alt key along with the underlined letter to select a particular item on the first in a sequence of menu selections. Do not press Alt again to activate a submenu.
Topic...Subtopic	Point and click your mouse inside the Help Browser for help on specific topics. Appendix B explains how to access the Help Browser and find more help in Maple.

1.4.1 Starting Maple

Maple provides two basic environments:

- Command Line, as shown in Figure 1-4. Consider using this text-based version when you have become more experienced with Maple or need to run only a few commands.
- GUI, as shown with annotations in Figure 1-5. This text will focus on this version.

To start the GUI version of Maple:

- Windows or MacIntosh: Click the Maple icon
- Unix or Linux: Enter **xmaple** or **maple -x** at the shell prompt

Refer to Waterloo Maple's website in Appendix H for a complete list of supported operating systems.

```

dis@mobius% maple

      | \ ^ / |      Maple 6 (SUN SPARC SOLARIS)
    . _ | \ | / | _ . Copyright (c) 2000 by Waterloo Maple Inc.
      \  MAPLE  /   All rights reserved. Maple 6 is a registered trademark of
    < _____ >  Waterloo Maple Inc.
      |           Type ? for help.

> Enter commands here. Exit with quit, done, or stop.

```

Figure 1-4 Command-Line Maple Interface

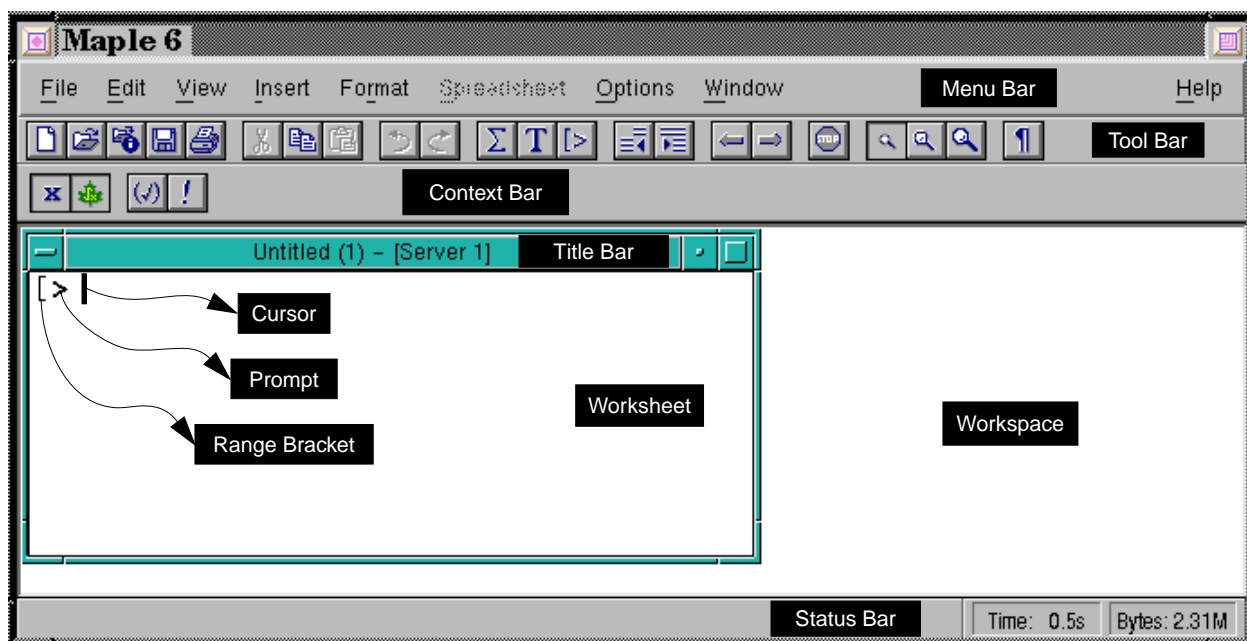


Figure 1-5 Maple Window

1.4.2 GUI Interface

You're about to take your first steps through Maple. Start up the GUI version of Maple and compare the window that pops up with Figure 1-5. Look at the following components of the window, summarized in Table 1-2.

Table 1-2 Elements of Maple GUI

Feature	Description	Reference
Menu Bar	Select commands with your mouse or the Alt key.	?menu
Tool Bar	Click on these icons for shortcuts. These icons change based on the tasks you perform, like accessing help or plots.	?toolbar
Context Bar	Change input and output formats, halt execution, and edit commands.	?contextbar
Title Bar	Click on the Title Bar icons for resizing, iconifying, and closing a worksheet.	?glossary
Worksheet	Create documents that communicate with Maple.	?worksheet
Workspace	Open multiple worksheets and other Maple windows.	?windowmenu

1.4.3 Item Selection

Maple uses two different methods to access menus with the mouse.

- A *left click* means that you press and release the left mouse-button (Windows and Unix) or the sole mouse button (MacIntosh) to select menus, worksheets, and items inside worksheets.
- A *right click* means that you press and release the right mouse-button (Windows and Unix) or press the Option key (MacIntosh) to perform other important functions discussed throughout this text.
- A *double* or *triple click* means that you rapidly left click two or times.

In general, to select a menu, move the mouse until the cursor points over the item and left click, unless a right click is specified.

Practice!

1. Which appendix in this book has solutions to Practice problems?
2. Locate and activate Maple on your system.
3. Which version of Maple do you use?

1.5 Help!

This section will help you become familiar with Maple's on-line help. A "seasoned" Maple user tends to rely on Maple's on-line help to answer questions, but many Help features assist the new and inexperienced users.

1.5.1 Help Menu

To investigate Maple's Help system, left click on the Help menu using your mouse. When first using Maple, select Help→BalloonHelp. Little balloons with helpful information will appear when you touch any icon and menu option. Eventually you will find these balloons irritating, but until you know every single one, I recommend leaving the balloon help on.

1.5.2 Tutorials

New Maple users should select Help→NewUser'sTour and Help→Introduction for an overview of Maple features. Chapter 2 of this book provides an overview also.



1.5.3 Help Browser



Maple has an excellent tool for finding help on commands called the Help Browser, as shown in Figure 1-6. You can open the Help Browser with the following actions:

- Select `H`elp→`U`singHelp and other menu selections, like `H`elp→`I`ntroduction.
- Type `?` or `??` at the Maple prompt (`>`) and press Enter or Return (`↵`).
- Find help on commands using `?command` or a text or topic search under `H`elp (See the following sections.)

The Help Browser organizes many of Maple's resources in categories called *topics*. Typically, topics describe commands with help on syntax, usage, and examples. Left click once on topics listed as Topic... in the left column to open *subtopics* that will appear to the right of the topics. You may also left click on the Tool Bar icons that appear below the workspace menus to move forward and backwards along topics. .

1.5.4 Sections and Subsections

Help topics typically organize information with *sections*, indicated by the icons  and . Sections collect text, execution groups, and other sections. *Subsections* are sections that are contained inside other sections.

- Left click on the  icon to expand a section.
- Left click on the  icon to collapse a section.

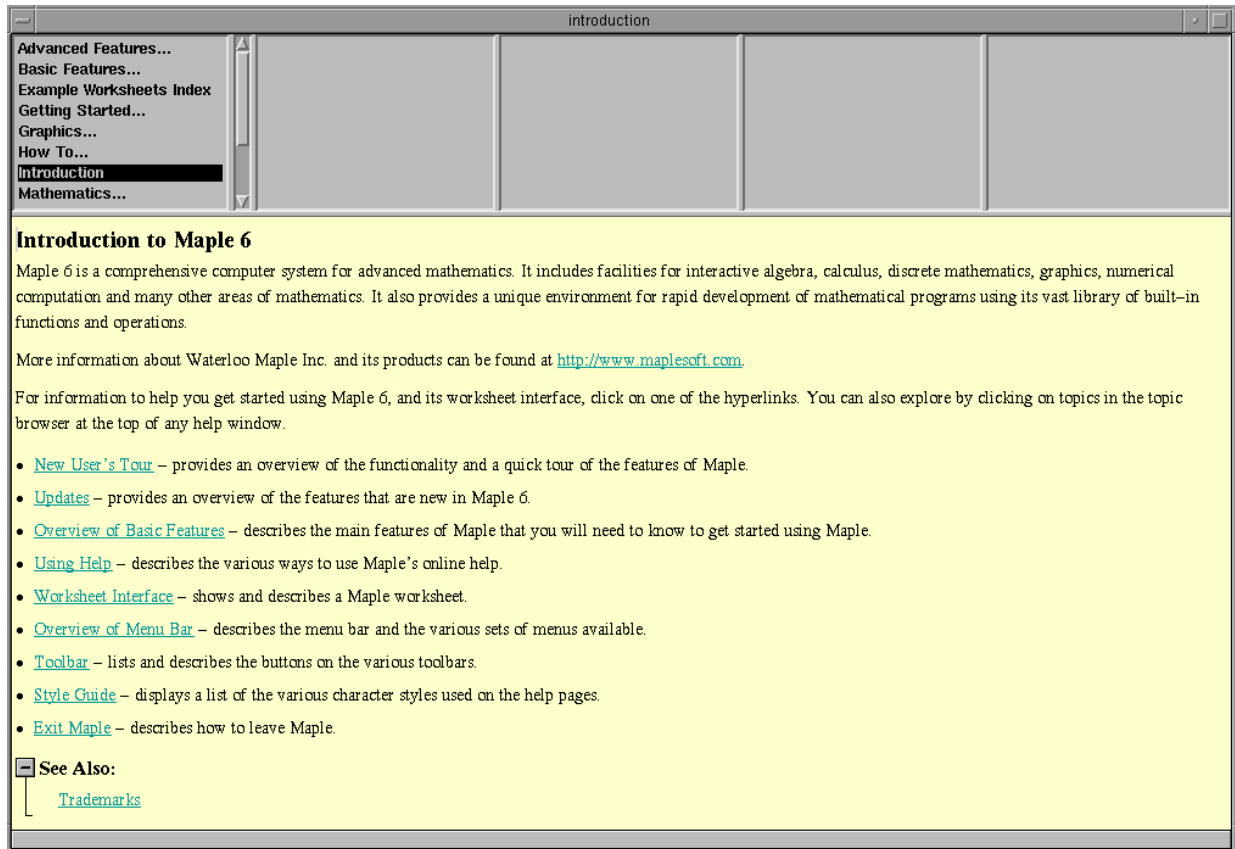


Figure 1-6 Help Browser

1.5.5 Hyperlinks

Many topics and other keywords are provided as *hyperlinks*. Hyperlinks are active text that “jump” to other topics or display information. Maple typically displays hyperlinks as colored, underlined text. Left click once to activate a hyperlink.

1.5.6 Command Line Help

Regardless of interface, you can enter **?topic** at the Maple prompt (>) for help on **topic**:

- Type a question mark (?) followed by **command**.
- Press the Enter or Return key (↵).

Figure 1-7 demonstrates how to get help on the **sqrt** command. At the prompt you would type **?sqrt** and then press ↵. Maple pops up the Help Browser with the appropriate Help page loaded. If you are uncertain of the topic name, which is usually a command-name, just type one or two letters. Maple will display all topic names that start with those letters. .

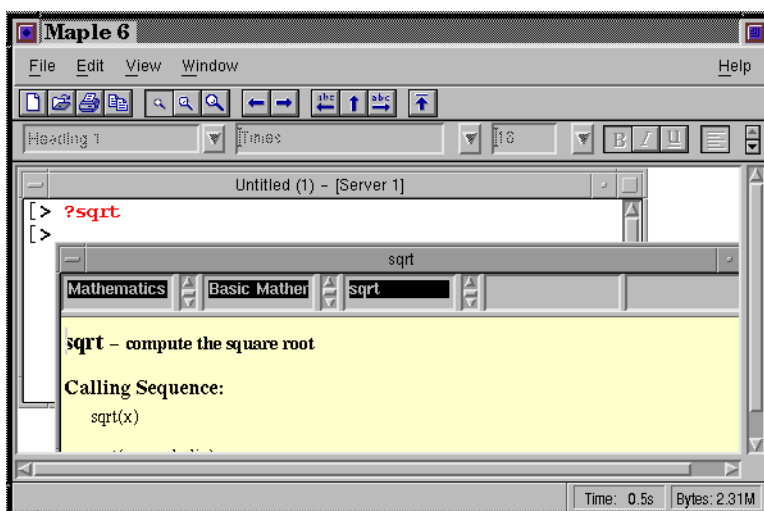


Figure 1-7 Getting Help on a Topic

1.5.7 Topic Search

Select **Help**→**TopicSearch...** to search for topics, such as command names. You should type a few letters of the topic name in the box next to **Topic**. As long as the **Auto-Search** feature is activated, Maple will automatically search for matching topics as you type the letters. For instance, try searching for **dis**, as shown in Figure 1-8. Maple will suggest topics that appear below such as **disassemble** and **discont**. Double-click on the topic names to investigate Maple's suggestions. If you select **discont**, Maple will pop open the Help Browser with the **discont** topic-page loaded.

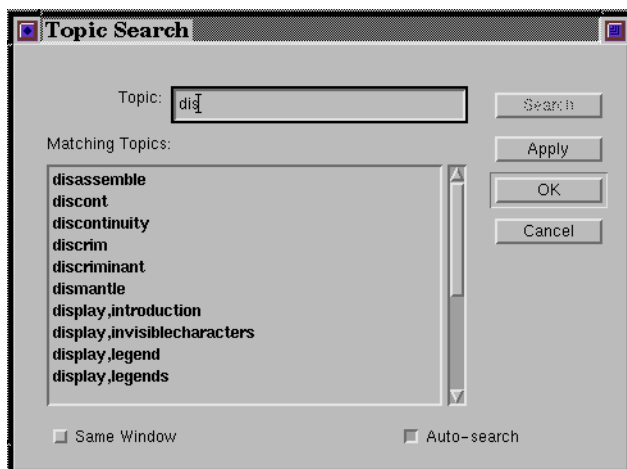


Figure 1-8 Topic Search

1.5.8 Text Search

If you are uncertain of a topic or command name, try a text search with `Help→FullTextSearch...` In the box next to `Word(s)`, type the words for which you are searching and press the `Search` button. Maple will suggest topics that might match your inquiry. Double-click on a topic to open the Help page associated with the topic.

1.5.9 Examples

Maple provides many example worksheets that cover a wide variety of topics and applications. For on-line examples, enter `?examples[index]` at the prompt. For a much larger directory, refer to the *Maple Application Center* at Maple's website site, listed along with other web resources in Appendix H.

Practice!


4. What Help topic in Maple contains the word *suck*? (Yes, there really is one.)
5. Activate `Help→BalloonHelp`. Point your mouse on an icon and on a menu. What happens?

6. Activate `File→AutoSaveSettings`. What happens when you select this menu option?

1.6 The Maple Worksheet

The Maple *worksheet* provides your main interface for communicating and working with Maple. In a way, a Maple worksheet resembles a document you would create with a word processor. At the prompt, you may enter commands, find help, and write text to create documents that contain commentary and the results of computations. This chapter explores many of these features as described in `?worksheet`, `?worksheet[interface]`, and `?worksheet[management]`.

1.6.1 Creating a Worksheet

By default, Maple starts with an empty worksheet. To work on a different worksheet, create a new worksheet by selecting the icon  or menu `File→New`. During a session, Maple labels each worksheet as “Untitled [number]” on the Title Bar in ascending order according to newness.

1.6.2 Workspace

Select `Window` options to organize and rearrange worksheets and all other Maple windows inside your workspace. For instance, try opening a few worksheets inside a Maple workspace. You may then select `Window→Tile` to display all windows next to one another in a tile-pattern.

1.6.3 Moving Around Your Worksheet

Generally, you may move around your worksheet by

- Pointing and clicking the mouse inside the worksheet
- Pressing the arrow keys to change the position of the cursor

Avoid moving the cursor with the Backspace, Del, and Enter (↵) keys. In the Help Browser, consult `BasicFeatures...Navigation...` for further information on other ways to move around the worksheet. Eventually, you should investigate keyboard shortcuts using `?hotmac`, `?hotunix`, or `?hotwin`.


1.6.4 Editing

To perform editing functions, like copying, cutting, and pasting, use the mouse to highlight portions of your worksheet:

- Move the mouse to the portion of the text you wish to edit.
- Left click the mouse.
- Drag the mouse over the portion you are editing

You may select `Edit` or the Tool Bar icons for many editing operations. You can also delete items by selecting them with your left mouse button and pressing the Del and Backspace keys. Consult `?editmenu`, `?documenting`, and `?toolbar` for more information.

1.6.5 Saving

Save your work! You never know when the system might crash. Select the icon  or the menu

`File→SaveAs...` to name and save worksheets, as shown in Figure 1-9:

- `F`olders or Directory: Change folders and directories by double-clicking on the folder name.
- File `n`ame: Delete the asterisk (*) and type a name that ends with `.mws`, like `hw1.mws`.
- Save file as `t`ype or Filetype: Leave the type on Maple Worksheet. Worksheets saved in this format preserve the entire contents in a format you open directly into Maple. See Section 1.6.7 for more information on Maple's worksheet format.

Click on OK when your chosen file name satisfies you. The new name will appear on the left side of the Title Bar on the worksheet. Once you have named your worksheet, frequently select `File→Save` to save your work. For more information, consult **?worksheet, managing, saving**.

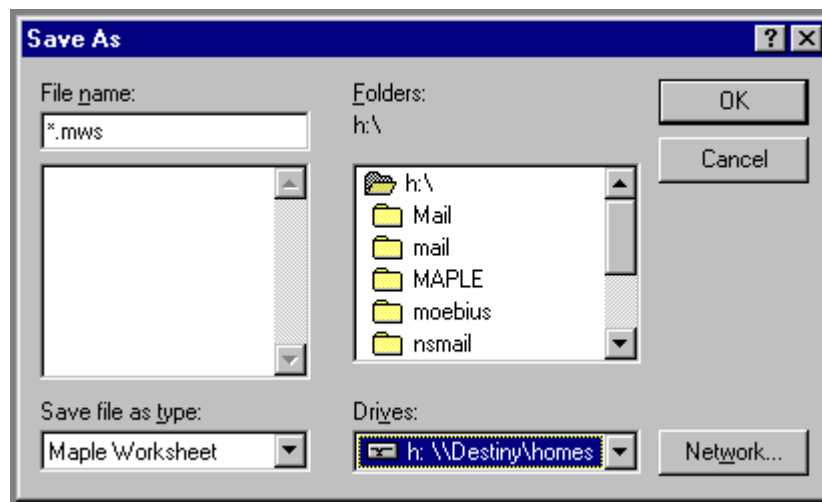


Figure 1-9 Save Worksheet

1.6.6 Exporting Worksheets

You can save your work to different formats by selecting `File→ExportAs...` If you prefer, you can

also select `File`→`SaveAs...` and then save the worksheet to another type of file. Note that exporting a worksheet to another format only exports the current version of your work. You have to export your worksheet again if you wish to incorporate changes inside the saved file. Some common formats include:


- Maple Worksheet (MWS): *Maple Worksheet format* (See next section.)
- HTML: Convert your worksheet to HTML for the World Wide Web. See `?xprt2html` for more details.
- Maple Text: A text-based representation of the Maple worksheet. Save in this format the worksheet needs to be imported back into Maple. The command-line version of Maple typically saves in this format. In general, you should stick to using MWS, instead.

Consult `?worksheet,managing,export` for more information about these and other formats.

1.6.7 Worksheet Format (MWS)

When you save a worksheet in the type called “Maple Worksheet,” Maple stores that worksheet’s contents into a text file that only Maple understands. These files, which typically have the extension `.mws`, are written as ASCII, which is a universally understood form of text. However, text written in MWS-format is unintelligible and will produce garbled printouts. You should only print MWS files from within Maple, as discussed in Section 1.6.9.

1.6.8 Opening Worksheets

Load previously saved worksheets by selecting the icon  or menu `File`→`Open`. The window that pops up, shown in Figure 1-10, resembles the “Save As” window. Select a directory by clicking

on Folders or Directory. “Open” automatically lists files with **mws** extensions. Click on an existing file or type the name of a file under File name. Click on OK to load the worksheet. For information, consult **?worksheet ,managing ,export**.

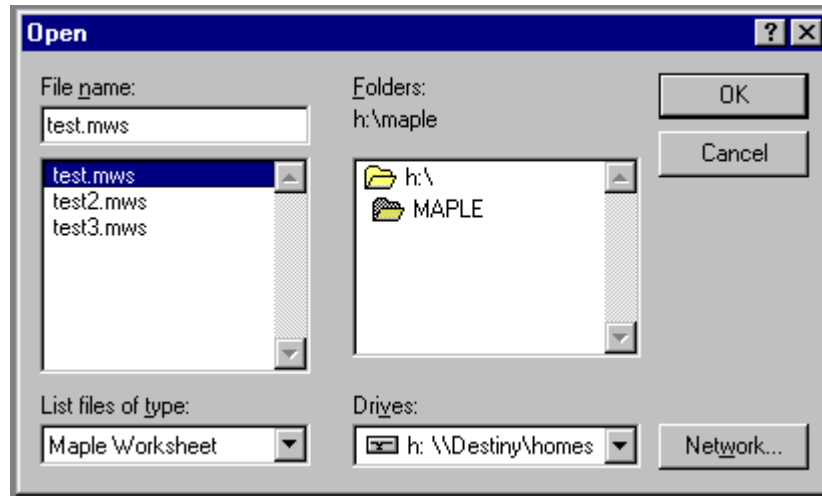




Figure 1-10 Open Worksheet

1.6.9 Printing

Print your worksheet by selecting the icon  or menu File→Print.... From the “Print” window shown in Figure 1-11 you have two choices for printing:

- **File:** Click on Print to file (Unix users should select Output to File.) A checkmark (✓) will appear in the box to the right. (For Unix users, an indented diamond ) Then, click on OK. Maple then creates a PostScript file containing the contents of your worksheet. Maple will then prompt you to enter a file name. Choose a name, like **something.ps**. See the next section for further description of PostScript.
- **Hardcopy:** Ensure that the Print to file box has no checkmark (✓). Then, click on OK. (Unix users should select Print Command and then enter `lpr -Pprinter` or `lp -dprinter` in the box to the right.)

Also, try `File→PrintPreview...` to view a file before printing it.

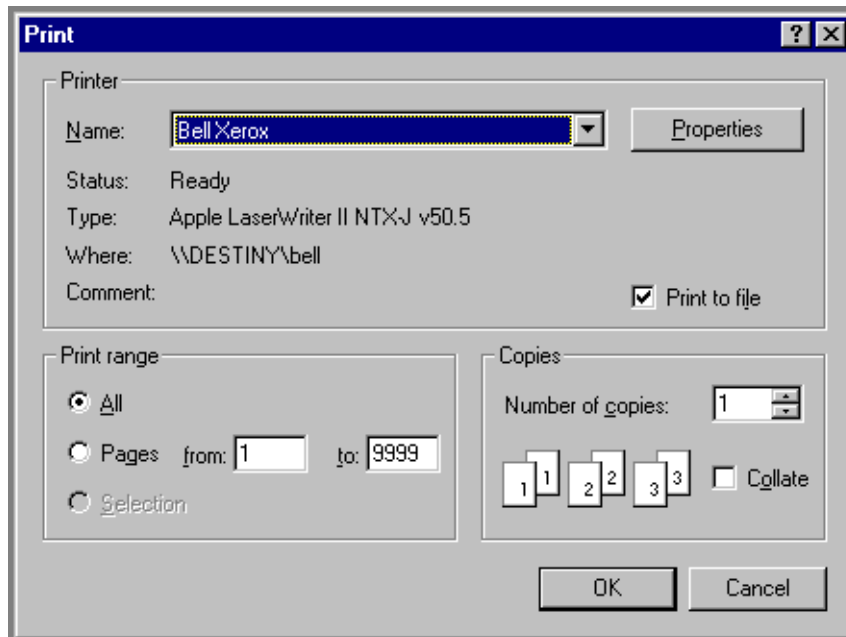


Figure 1-11 Print Worksheet

1.6.10 PostScript

PostScript (PS) is another kind of text-based formatting that creates files that print on virtually every kind of printer. The first line in a PS file typically starts with `%!PS-Adobe`. Beware of the difference between PostScript and Maple's MWS files! Maple cannot open PostScript files, so always retain both PostScript and MWS versions of your worksheets. Remember, also, you should never directly print a file stored in MWS format unless you use Maple's `File→Print...` command sequence!

1.6.11 Quitting Maple

To end your Maple session, enter `File→Exit`. Maple will then prompt you to save unsaved

worksheets. When using the command-line version of Maple, enter **quit**.

Practice!

7. Create a new worksheet.
8. Save the worksheet to a file called **templ.mws**. What type should you pick for the file?
What does the Title Bar for the worksheet now display?
9. Print the worksheet to a file called **templ.ps**.
10. Close the worksheet.
11. Re-open the worksheet. Can you load the file called **templ.ps**? Why or why not?
12. Exit from Maple.

Summary

- A variety of tools help solve science and engineering problems.
- Tools include both physical devices and abstract methods.
- Computer programs implement models derived from scientific principles and experimentation to ease analysis and improve accuracy.
- Computer algebra systems provide both symbolic and numerical analysis.
- Maple is a computer algebra system.
- Three basic components – the kernel, libraries, and interface – form Maple.
- You may search for help using Maple's Help Browser, which accessed via the Help menu or the prompt (?).
- You should save worksheets in Maple's own MWS format, but you may not print those files. To print a worksheet, you may use File→Print...

Key Terms

analytical method

computer

computer algebra system (CAS)

engineering

experimentation

graphical user interface (GUI)

Maple

Maple interface

Maple library

Maple kernel

Maple Worksheet format (MWS)

mathematics

models

numerical model

PostScript (PS)

science

symbolic model

tools

worksheet