CHAPTER 1

Running Maple

Computer Systems

What Computer System Are You Using?

Maple software runs on almost every major computer system including mainframes and desktop systems. Maple can also be set up to run across a network and even between systems. Almost all implementations of Maple are graphically-based systems where you can both type on a keyboard and use a mouse to navigate a window (e.g., desktop systems running MS Windows, the MacOS or a Linux-based system.) The Maple commands we discuss in this guide will work on all of these implementations.

> **Note:** Text-based implementations of Maple are also available. These are often found on mainframe systems, and are usually of interest only to people who are doing remote logins, or to advanced users who want the performance advantage that comes from using a text-based system.

Starting the Software

You should follow the instructions that came with the Maple software to install it on your computer system. Once you've completed the installation, you're ready to explore Maple.

Starting Maple obviously depends on the system you are using.

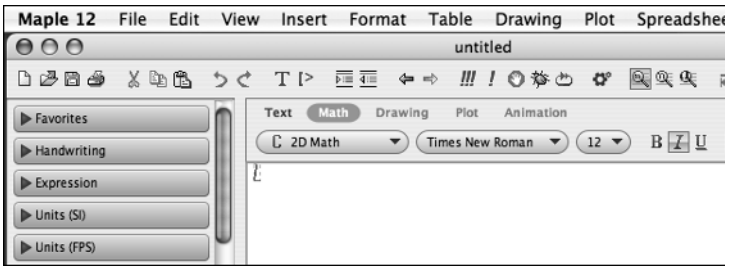
- On most PCs and Macintosh computers, you will typically find the icon of the Maple application in a window. Click (or double-click) on the icon.
- On Linux, or other command-line operating systems, you will usually enter the command **`xmaple`** or **`maple`** (or a local equivalent, depending on how the software has been installed and how your system is configured).

> **Note:** If you run Maple over a network, you may need to check with your system manager for the starting procedure.

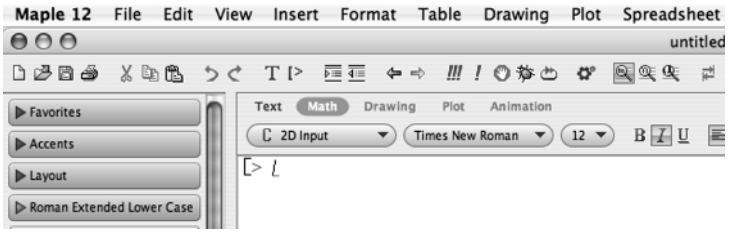
If this is the first time you start Maple, you will be presented with the choice to open a document or a worksheet. In the document mode, you can mix Maple's computation with your text to create an interactive document. In the worksheet mode, Maple's input has to be entered line by line in groups. (Please see the graphics of these two modes on the next page.)

Document is the default mode, but we find that beginners are more comfortable with the worksheet mode. Nevertheless, the Maple input we discussed in this book will work on both modes. If you want to switch from one mode to the other, check the Q & A section at the end of this chapter.

When Maple is launched, a new window will be opened with the cursor flashing, awaiting your input.



Document Mode



Worksheet Mode

Notice that in the worksheet mode, Maple gave you the prompt symbol ">" automatically. You don't enter it yourself.

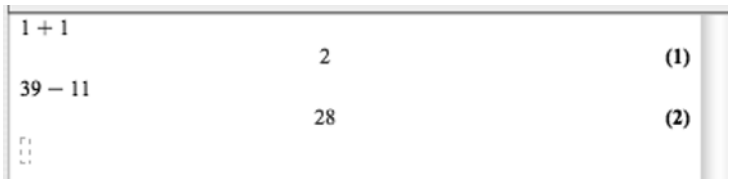
Input and Output

Maple is interactive software. For almost every entry you make, Maple will provide a direct response. Once you launch Maple and see the flashing cursor, you can type the three characters 1 + 1 and then press the evaluation key (either the *enter* or *return* key, depending on your computer system). Maple will give you the response "2" on a new line, and your window should look something like this:

Document Mode

Worksheet Mode

Now you enter the characters 39 - 11 and then press the evaluation key again (*enter* or *return*) and you'll see the result of 28:



Document Mode

Worksheet Mode

Throughout the rest of this manual, we will not show you windows. Instead, we'll show all of our input, with the response in plain text. Thus, our sequence above would be listed as:

Keystrokes: **1+1** *enter*

1 + 1

2

Keystrokes: **39-11** *enter*

39 – 11

28

Quit

When you've had enough and want to exit Maple, you can simply choosing the **Quit Maple** item in the **Maple** menu on the top of the screen. On a text based system, simply execute

```
quit
```

2-D Math Input

By default, Maple opens in 2-D Math input mode in a document. This allows you to enter the input in the same way as you would write it mathematically. As a result, you can use Maple with a minimum of syntax and mix mathematical notation with text for explanation. For example, to compute $\frac{2}{3}+1$, as you begin to type

```
2/
```

the input on the screen will automatically turn to the fraction form as shown below with a flashing cursor at the denominator waiting for your input.

$\frac{2}{\_}$

You can now enter **3** in the denominator. Press $\rightarrow$ (the right arrow key) on your keyboard and the cursor returns to the central position. Now type **+1**. You will see

$\frac{2}{3}+1$

Press the evaluation key *enter* and Maple responds with

$$\frac{5}{3}$$

As another example, to enter $x^2 + 3x$ in 2-D Math mode, you will type **x^2** then press [→], and finish the typing with **+3*x** to see the input:

$$x^2 + 3 \cdot x$$

(When you type **^**, the cursor will move to the superscript position. Press [→] to make the cursor move out of the superscript position.)

A Quick Tour

For the rest of this chapter, we'll show you some of Maple's capabilities. We present these examples only to whet your appetite. You can follow along at your computer by typing (exactly!) what we show below. In later chapters, we'll give you a more complete explanation of how to use these commands and how to use palettes to graphically produce the commands.

Note: When you input the following commands in Maple, make sure that:

- You use upper- and lower-case characters exactly as we do. Maple is very "case sensitive." If you use the wrong capitalization, Maple won't understand what you mean.
- Use exactly the type of brackets we show. There are three types of brackets: **[** *square brackets* **]**, **(** *parentheses* **)** and **{** *curly braces* **}**. Each has its own meaning in Maple. If you use the wrong one, Maple will be confused.
- You can continue input from one line to another in Maple by pressing either [*shift - return*] or [*return*] (depending on your system). For our examples, we recommend that you break lines exactly as we show in the text.
- You must always press the evaluation key [*enter*] to see the output.
- Your output might appear slightly different from ours in some of the following examples. We explain why in Q & A at the end of this chapter.

Calculator

Maple does all the work of a hand-held electronic calculator. You can enter numerical expressions and Maple will do the arithmetic:

Keystrokes: **235.567*441.235/623.45** [*enter*]

$$\frac{235.567 \cdot 441.235}{623.45}$$

166.7181092

Keystrokes: **sin(0.3)** [*enter*]

sin(0.3)

0.2955202067

But Maple can go much further. Try this factorial computation!

Keystrokes: **289!** *enter*

289!

207986607530614516434889573226252709222712518908365286496652422317\
405760295930638776430109826354519132675660433931363055910963871453\
772379754931444766652739192303201763588723618347593740385428725846\
122572271049818916876323493243976023302916666394540247449307010665\
731331903556896427962603583291932028351318888786128689538489086713\
005449989591695585446014805881310771610743578696897019623882572957\
311572603371048376255338230572538584588079078669943174850854858995\
580594914244562856410918607028520410684463210865874698240000000000\
000000000000000000000000000000000000000000000000000000000000000000

Your calculator cannot do this!

Solving Equations

Maple can solve complicated equations and even systems of equations in many variables. For example, the equations $2x + 5y = 37$ and $x - 3y = 21$ have a simultaneous solution:

Keystrokes: **solve({2*x+5*y=37,x-3*y=21},{x,y})** *enter*

$$solve(\{2 \cdot x + 5 \cdot y = 37,\ x - 3 \cdot y = 21\},\ \{x, y\})$$

$$\left\{x = \frac{216}{11},\ y = \frac{-5}{11}\right\}$$

Maple can also find solutions to equations numerically. For example, the equation $x = \cos(x)$ has a solution very close to $x = 0.75$. We can find it with:

Keystrokes: **fsolve(x=cos(x),x)** *enter*

$$fsolve(x = \cos(x),\ x)$$

$$0.7390851332$$

You will learn more about solving equations in Chapter 6.

Algebra

Maple is very good at algebra. It can work with polynomials:

Keystrokes: **expand((x-2)^2** → ***(x+5)^3** → **)** *enter*

$$expand((x-2)^2 \cdot (x+5)^3)$$

$$x^5 + 11x^4 + 19x^3 - 115x^2 - 200x + 500$$

Note: Use → after the **2** to move out of the superscript. The → will also move you out of the denominator of a fraction or the radical of a square root.

Keystrokes: **factor(x^5 → +11*x^4 → +19*x^3 → -115*x^2 → - 200*x+500)** *enter*

$$factor(x^5 + 11 \cdot x^4 + 19 \cdot x^3 - 115 \cdot x^2 - 200 \cdot x + 500)$$

$$(x-2)^2(x+5)^3$$

Are you impressed? Maple also knows standard trigonometric identities such as $\sin^2(x) + \cos^2(x) = 1$:

Keystrokes: **simplify(sin(x)^2 → +cos(x)^2 →)** *enter*

$$simplify\left(\sin(x)^2 + \cos(x)^2\right)$$

$$1$$

Note that $\sin(x)^2$ means $(\sin(x))^2$ and is different from $\sin(x^2)$.

That one was easy, but you probably forgot that $\sec^2(x) - \tan^2(x) = 1$:

$$simplify\left(\sec(x)^2 - \tan(x)^2\right)$$

$$1$$

You will learn more about doing algebra in Maple in Chapter 5.

Calculus

Maple even knows a lot about calculus! We can find the derivative of the function $f(x) = x/(1+x^2)$.

Keystrokes: **diff(x/(1+x^2 →) → ,x)** *enter*

$$diff\left(\frac{x}{(1+x^2)}, x\right)$$

$$\frac{1}{1+x^2} - 2\frac{x^2}{(1+x^2)^2}$$

A complicated integral such as $\int \frac{1}{1+x^3}\,dx$ is handled rather easily.

Keystrokes: **int(1/(1+x^3 →) → ,x)** *enter*

$$int\left(\frac{1}{1+x^3}, x\right)$$

$$-\frac{1}{6}\ln(x^2 - x + 1) + \frac{1}{3}\sqrt{3}\arctan\left(\frac{1}{3}(2x-1)\sqrt{3}\right) + \frac{1}{3}\ln(1+x)$$

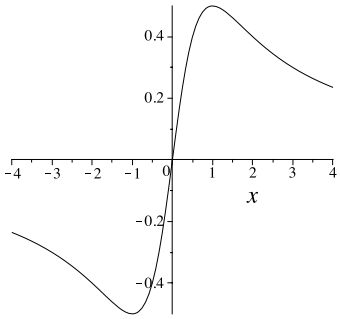
In Chapter 2, we will show you how to use palettes for differentiation and integration. Chapters 12 through 15 demonstrate many of the Calculus capabilities of Maple. The Appendix A also contains information on Maple commands useful for learning Calculus.

Graphing in the Plane

Maple does everything a standard graphing calculator does and does it better. For example, to see the graph of the function $f(x) = x/(1+x^2)$ over the interval $-4 \le x \le 4$, you can use:

Keystroke: `plot(x/1+x^2` → → `,x=-4..4)` *enter*

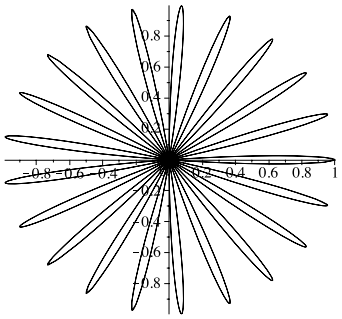
$$plot\left(\frac{x}{1+x^2}, x = -4..4\right)$$



We can see a "daisy" with:

Keystroke: `plot([cos(21*t)*cos(t),cos(21*t)*sin(t),t=0..2*Pi])` *enter*

$$plot([\cos(21 \cdot t) \cdot \cos(t),\ \cos(21 \cdot t) \cdot \sin(t),\ t = 0..2 \cdot Pi])$$



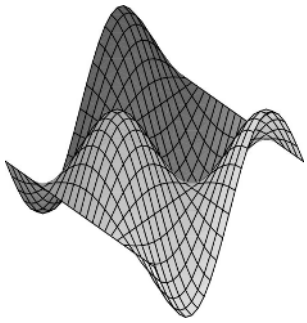
Chapters 9, 10, and 11 contain the details of the two-dimensional plotting capabilities of Maple.

Plotting in Space

Maple does a wonderful job with three-dimensional graphics. Let us show you two examples.

Keystrokes: `plot3d(sin(x)*cos(y),x=0..2*Pi, y=0..2*Pi)` *enter*

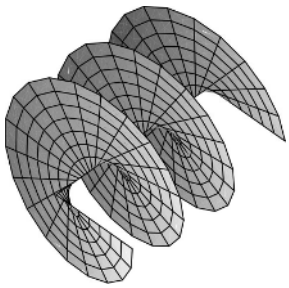
$$plot3d(\sin(x) \cdot \cos(y),\ x = 0..2 \cdot Pi,\ y = 0..2 \cdot Pi)$$



Keystrokes: `plot3d([t,r*cos(t),r*sin(t)],r=0..1,t=0..6*Pi,` *shift - return*

`grid=[8,60])` *enter*

$$plot3d([t,\ r\cdot\cos(t),\ r\cdot\sin(t)],\ \ r=0..1,\ \ t=0..6\cdot \mathrm{Pi},\ grid=[8,60])$$



Chapters 16 and 20 contain most of the information you need to create three-dimensional pictures.

Changing the 3-D View

If you click and drag the mouse button with the cursor/arrow at any point inside a 3-D picture, the picture will rotate according to how you move the mouse. This allows you to see the 3-D picture from any viewpoint.

Chapter 20 contains more information on how you can utilize Maple's interface to more easily control your view of 3-D graphics.

Programming and Simulation

Maple has its own programming language. You can use it to write code just as you would in Java, C or BASIC. Here's a simple routine to simulate the flipping of a coin several times and return the number of heads observed:

Keystrokes: `coinflips := proc( howmany )` *shift - return*

`local heads;` *shift - return*

`heads := 0;` *shift - return*

`from 1 to howmany do` *shift - return*

`if RandomTools[Generate](choose([head,tail]))` *shift - return*

`=head then` *shift - return*

`heads := heads + 1;` *shift - return*

```
end if; shift - return
end do; shift - return
printf("%a heads seen in %a flips", shift - return
     heads, howmany ); shift - return
end proc; enter
```

You can use this routine:

Keystrokes:
```
coinflips( 100 ); enter
                  55 heads seen in 100 flips.
```

Keystrokes:
```
coinflips( 1000 ); enter
                  491 heads seen in 1000 flips.
```

Chapter 27 introduces the basic features of the Maple programming language.

More Examples

The "More Examples" sections of this guide present examples involving more mathematics. Students of mathematics, science, and engineering may find these of interest.

Here's one such example. Not too many people know about the Bessel functions. But if you're learning physics, you might want to know what Maple has available for you in Bessel functions.

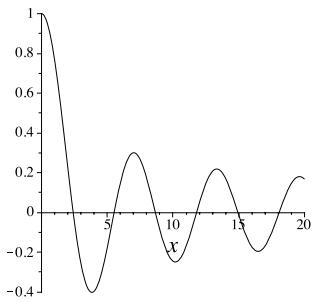
Special Functions

The Bessel function of order 0, $J_0(x)$, is a solution to the differential equation:

$$x^2y'' + xy' + x^2y = 0\,.$$

You can see its graph with:

Keystrokes:
```
plot(BesselJ(0,x),x=0..20) enter
```



The smallest, positive zero of $J_0(x)$ is at approximately $x = 2.40483$:

Keystrokes:
```
fsolve(BesselJ(0,x)=0,x=1) enter
                  2.404825558
```

Useful Tips

If you want to try the examples in this book, you don't have to enter the Maple input one by one by hand. We've made available copies of the Maple documents and worksheets used to create the inputs you see in this Guide. After downloading them, you can copy and paste into your own Maple document and begin experimenting. Please visit the authors' websites mentioned in the Preface.

Troubleshooting Q & A

Most chapters of this guide end with a Troubleshooting Q & A section, where we answer some common questions we think you will have. But there's not too much you can ask yet, except:

Question... Maple is giving me unexpected evaluations when I use trigonometric or other named functions in 2-D Math. What am I doing wrong?

Answer... A common mistake when entering 2-D Math input is to carelessly leave a space between the function name and the left parenthesis. In 2-D Math input a space is implied multiplication, but it may be hard to see. For example:

Keystrokes: **`sin(1.2)`** *enter*

sin(1.2)

0.9320390860

But if you type a space, then the answer will be very wrong.

Keystrokes: **`sin`** *space* **`(1.2)`** *enter*

sin (1.2)

1.2 sin

Question... Suppose I make a mistake in the input, or I do not finish the entry, but I hit *enter* anyway. How will Maple respond?

Answer... Most likely you will get an error message from Maple. Don't worry. You can simply move the cursor back to your input, correct the mistake or continue the typing to finish the input.

Question... The output I get when testing some of the examples in this text does not look exactly like what's shown here. What's going on?

Answer... All the outputs we shown in the text are from the document mode of Maple 12. If you use a different version of Maple, or use the worksheet mode instead, you may

get an output in a different format or arrangement. However despite this inconsistency, the actual computation and the final result should not be affected.

Question... If I set up the document mode as the default, how can I start Maple with worksheet mode instead, or vice versa?

Answer... No matter whether you are in a document mode or worksheet mode, you can always open a new document or worksheet by choosing **File** → **New** → **Worksheet Mode** or **Document Mode** from the menu bar.

You can also reset the default style of user interface that Maple starts by default. To do this, click on the **Tools** menu and select the **Options ...** entry from the list. A popup window will appear. Now, click on the **Interface** tab and look for the drop-down list labeled by "**Default format for new worksheets:**". Select **worksheet** or **document**, then click **Apply Globally**.

Question... What do I do now?

Answer... Turn the page and start learning about Maple!