A BRIEF INTRODUCTION TO MAPLE R. Sachs, Fall 2004

1. What is MAPLE?

MAPLE is mathematics software designed to perform symbolic and numeric operations. It provides many programming capabilities.

2. Why do we use MAPLE?

MAPLE enhances mathematics instruction by providing high quality graphics, easily implemented procedures, computational capability, and the ability to create documents which incorporate mathematics (including graphics) into the text rather easily. MAPLE has many advanced features which will not be used by beginning students but may be of considerable use in later courses.

3. Running MAPLE

You will be using MAPLE in a window environment, either MS-Windows, Macintosh, or the unix x-windows. MAPLE will run similarly in all these settings except for the details of how windows are accessed and controlled. MAPLE worksheets will cross platforms, so your PC work can be transferred to unix or Mac.

MAPLE creates a worksheet, which will consist of input (from you) and output (from MAPLE). Most of the interesting input is in the form of commands, which are executed by MAPLE. Text can be included as well. You tell MAPLE to go and execute a command by the punctuation symbols semi-colon or colon. The semi-colon will display MAPLE's output. The colon will not. This is sometimes useful for long or messy intermediate steps.

Each command changes the state of MAPLE, which "remembers" earlier work. So if the variable name x was given the value 3 previously, later uses of x will be read as 3, unless you change the value or "unassign" the name.

Worksheets are easily saved and retrieved. This would be done by the local window pull-down menu. A saved worksheet can be reloaded using the "open" button. WARNING: Reloaded worksheets are not automatically re-executed. To re-execute individual commands, go to that line and hit the return key; to re-execute the whole worksheet, use a pull-down button.

For the rest of this introduction, we will use the input line prompt symbol of a greater than sign > to indicate the usual MAPLE state of awaiting your next command. MAPLE output will be indented and appear below commands.

Some other aspects of MAPLE to be aware of: Capitals and lower-case letters are viewed as different; some names are reserved or defined already, so name things carefully; some important constants are named, always with first letter capitalized, such as Pi, E, and I.

4. Arithmetic in MAPLE

MAPLE performs arithmetic in several different modes, unlike most calculators. Rational numbers are usually evaluated as rational numbers and not converted to decimals unless the user requests the conversion. Similarly, algebraic expressions like the square root of 2 and special constants like Pi will usually be written that way until the user requests a conversion. As well, for decimal representations MAPLE allows the user to declare how many digits of accuracy to attempt to maintain.

The order of operations in MAPLE is the standard one in mathematics as opposed to some calculators. **To avoid ambiguity or unintended output always use parentheses**.

5. Functions and expressions

The heart of MAPLE's symbolic capability lies in the ability to define and manipulate **functions** and **expressions**. These two related MAPLE objects are easily confused, especially by beginning students/users. In this introduction, only the basic aspects of symbolic manipulation will be described.

An **expression** is a single value, an unknown or a string of letters. MAPLE will perform many operations on expressions, so you will be using them often. MAPLE will allow the equality sign = as part of an expression, so you can type things like

```
> x = y + 3;
                x=y+3
> x;
                x
```

and MAPLE will evaluate the first input as an **equation**. **This does not tie the values x and y together!**

A different format is used for the operation of **assignment**. To **assign a value to a name**, you must type the combined symbol of a colon followed by an equal sign. Thus if MAPLE knows that y has value 2 and you type the assignment for x seen below, which looks a lot like the previous equation, MAPLE evaluates the right hand side and then gives that value to x:

```
> x := y + 3;
                x:=5
```

A **function** is a special data type in MAPLE. Functions can be defined in several different ways, the most simple being when the function has a simple expression relating input to output. For such functions, you just use a **special arrow symbol** made by typing the two keys minus and greater than in order with no space in between. Thus to define the function that adds three to any input, we use the assignment (:=) and the function symbol (− >) as in the following command line:

```
> f := x− > x + 3;
```

The name x is a dummy variable so the same function f is defined by:

```
> f := y− > y + 3;
```

The main confusion in MAPLE about functions and expressions comes about because the common usage will yield an **expression** as the evaluation:

```
> f(x);

                x+3
```

when **f is the function** defined previously and **x has no assigned value**. If MAPLE doesn't yet know what f is, it will echo f(x) as its evaluation instead. On the other hand, if x has an assigned value, evaluating the expression f(x) will give the function f at the value assigned to x.

MAPLE's fussiness about this leads to some strange outcomes when things are not defined well. If MAPLE cannot evaluate f(x) in a plot command, rather than plot anything, you get a cryptic message about an empty plot. When f(x) is part of an expression rather than defined as a function, as in the following sequence of inputs and outputs (with f not previously defined), MAPLE doesn't recognize f(3) since only the literal input x appears in the first line.

```
> f(x) := x + 3;
                f(x):=x+3
> f(3);
                f(3)
```

This contrasts with the similar inputs defining f as a function using − >, which would lead to the more expected output for f(3), namely 6.

6. The student package

A wide variety of valuable procedures are part of MAPLE's student package. If it isn't loaded already, it can be loaded at any time using the command

```
> with(student) :
```

If you use a semi-colon, MAPLE will list all the new names now loaded. **You will use some of these commands in this course**. **TIP**: If you try a command and get no action, just an echo, try loading the package.

7. On-line help

MAPLE provides on-line help, available either through the windows menus or by the input ?command-name where command-name means the command you need help with. For example, to learn more about plot, type

> ?*plot* (the semi-colon is optional)

The pull-down help menu has a browser feature to help you find what you need.

8. A brief tutorial session

Here is a set of commands to define a function, compute some values and draw some graphs. To execute this set of commands, be careful to check that your typing is correct. Computers cannot handle typos well!!

The comments appearing in parentheses after the semi-colons should not be typed. They are here for your benefit.

> $t := 3;$ (assign the name t the value 3)
> $t^3;$ (evaluate the cube of t)
> $Pi;$ (evaluate the built in constant Pi)
> $evalf(Pi);$ (convert to a floating point/decimal)
> $sin(Pi/2);$ (sin is a built-in function)
> $f := x- > x^2 + 3 * x + 2;$ (define the function f)
> $f(1);$ (evaluate f(1))
> $f(3/2);$ (MAPLE does rational arithmetic)
> $f(1.5);$ (decimal input gives decimal output)
> $plot(f, -3..3);$ (plot f with domain [-3,3])
> $f(x);$ (output is an expression)
> $plot(f(x), x = -3..3);$ (plot expression f(x) with domain [-3,3])
> $factor(f(x));$ (factor the expression f(x))
> $factor(f);$ (f is a function, not an expression)

9. Most common problems for beginning users

Computers are fussy and do not guess at intended input. They are also not very good at diagnosing problems when they happen. Users need to be ready to find the problem and fix it themselves. On the other hand, computers are usually very reliable, so it rarely helps to repeat the exact same steps more than once. Debugging is an art more than a science, so there are few rules for getting unstuck. Here are some tips based on experience in MAPLE:

If your input is echoed back, MAPLE cannot evaluate something. Go back and check if you defined it. If so, make sure MAPLE took that input in the way you meant it. Remember: = is not :=

If your plot command didn't work, make sure that the function was defined and then check the syntax of your plot command. Recall that f and f(x) are different, f being a function and f(x) an expression.

Beware of cases of letters – MAPLE cares about that.

If some command is echoed back, MAPLE didn't recognize it. Try to load the command or package using the MAPLE command "with".

Be careful about punctuation and spelling, including parentheses.

10. Finding more information

There is a rapidly expanding set of MAPLE resources. Several good books are listed at the Maple corporate web page (www.maplesoft.com).

Heck, A., Introduction to Maple, 3rd edition, 2003 (Springer- Verlag).

Garvan, F., The MAPLE Book, 2001 (CRC press).

Putz, J., Maple Animation, 2003 (CRC press).

There are nice introductions and tutorials on the Web at the following academic sites:

http://www.indiana.edu/ statmath/math/maple/overview.html

www.kettering.edu/acad/scimath/appmath/maple/

The MAPLE corporate site (www.maplesoft.com) has a student resource page too:

www.maple4students.com