Instructions for Use of Maple in Mathematics 251

The computer program **Maple** was designed to take some of the drudgery out of mathematics: it can differentiate, integrate, and otherwise manipulate mathematical formulas, perform arithmetic calculations, plot curves and surfaces in two and three dimensions, solve differential equations, and carry out a variety of other useful mathematical operations. At Rutgers, Maple is available on the student computer **eden**. The instructions in this handout are for a special version of Maple, called **xmaple**, which is customized to run under the X windows system. This means that they apply when you are working on an x-terminal connected to eden.

Getting started: From an x-terminal in one of the public labs (e.g., in SERC or in the basement of the Hill Center) you should log in to **eden**, then start Maple by typing the command `xmaple &` (note that "xmaple" is in lower case; typing the & allows you to continue using your xterm window for other purposes while Maple is running). A Maple window will open. You can now give an instruction to Maple by placing the mouse pointer in this window (just to the right of the prompt >), typing a Maple command, and then typing a carriage return. Maple carries out the command and prints a response. For example, if you type `1 + 1;` , Maple will respond with **2**. Note that you must type a semicolon after each Maple command, to indicate that you have finished entering the command.

Since you will not be given a Maple manual, you should learn to use Maple either by running the Maple tutorial—type `tutorial()` at the Maple prompt—or by using the built in **Help** facility. For example, to learn how to use the `plot` command, type, after the prompt >, the command `?plot;` . A window will open describing the basic structure of the command and giving examples of its use. To close this window when you have finished with it, click the left mouse button on the word **File** at the top of the window and then drag the mouse down, releasing the button when **Exit** is highlighted. For brevity, this operation will henceforth be specified by saying "choose **Exit** from the **File** menu."

To continue, you will need to know some basic commands and syntax of Maple.

Arithmetic: The operations addition, subtraction, multiplication, division, and exponentiation are indicated by `+, -, *, /, ^` respectively. All grouping of expressions is done with the left and right parentheses (and). The product xy must be written `x*y`, not `xy` or `x y`; if you type `xy`, Maple assumes you are referring to a variable called "xy". Thus, to enter the expression $(2x + y^2)/(2x + e^x) + 1$ into Maple, you type:

```
(2*x +y^2)/(2*x + exp(x)) + 1;
```

Note that the exponential function is built into Maple and is referred to as `exp`. Similarly, Maple knows the functions `log`, `sin`, `cos`, `tan`, and many more standard functions.

When operating on integers, Maple does exact arithmetic, rather than using decimal approximations. To get a decimal approximation, use the Maple command `evalf`. The Maple command `evalf(4/7,20);` produces a 20 digit approximation to 4/7. Typing only `evalf(4/7);` will produce a 10 digit approximation—as will typing `4.0/7.0;` .

Algebra: To help you do algebraic manipulations, Maple has the commands `expand`, `factor`, and `simplify`, which you can learn about by using the **Help** facility. You can also solve algebraic equations by using the commands `solve` and `fsolve`.

User-defined Functions and Expressions: In Maple, `x^2 - 2*x +3` is an **expression**. You can assign a name to this expression for future use by typing `g:= x^2 - 2*x +3;` . To evaluate an expression at a particular value, use the Maple command `subs`. For example, `subs(x=2,g);` will produce the value 3.

To define a **function** in Maple, use the syntax `f:=x -> x^2 - 2*x +3;` . When the function f has been defined in this form, you can evaluate it at $x = 2$ by typing `f(2);` . To define a function of two variables, use the syntax `h:=(x,y) -> x*y + 2;` .

Plots: The basic plotting command in Maple is `plot`. This command has many forms, so you should look carefully at the examples given at the end of its **Help** page to get some idea of its flexibility. There are many other plotting commands in Maple; in this course we will use primarily `plot3d` and `implicitplot`. To use some of the plotting commands you must first issue the command `with(plots);` . For example, this is necessary in order to use the command `implicitplot`.

You can assign a name to a plot just as described above for assigning a name to an expression. Several previously named plots can then be displayed on the same graph by using the command `display`. Type `?plots[display]` for details.

Differentiation and Integration: In addition to performing basic calculations and evaluating standard functions, Maple can also differentiate and integrate functions. Maple has two commands for differentiation. The `diff` command operates on expressions. For example, `diff(x*y, x);` differentiates xy with respect to x. If you have typed `g:=x^2;` , then you may use `diff(g,x);` to differentiate g. If you have defined a function f with the command `f:=t->t^2`, then to differentiate with respect to t, type `diff(f(t),t);` . Note what happens if you type `diff(f,t);` . The command **D** can also be used to differentiate functions. See the **Help** page for examples.

The command for both definite and indefinite integration is `int`. If Maple cannot evaluate a definite integral exactly, numerical integration may be used. Type `?int[numerical]` for details.

Maple Worksheets: The window which appears when you start Maple is called a **Maple worksheet.** To complete each computer assignment in Mathematics 251 you are asked to turn in an edited printout of your work; such a printout can be obtained by editing, and then printing, your worksheet. The printout should include only the numerical, symbolic, and graphical output of Maple which is appropriate for the solution of the problems assigned, plus text material in which labels are provided for graphical output and explanations added. Maple includes various editing capabilities which should enable you to produce neat and coherent output, and which we now describe.

To remove an unwanted portion of your Maple worksheet (e.g., a region containing commands that you typed incorrectly or that were not directly relevant to the solution of the exercises), select the region to be deleted by clicking the left mouse button at the beginning, then dragging the mouse across to the end of the portion of the worksheet you wish to delete. Then choose **Cut** from the **Edit** menu. To copy a region to a new location, select the region as above, but now choose **Copy** from the **Edit** menu. Then click the left mouse button in the position in which you wish to insert your selected region and choose **Paste** from the **Edit** menu.

When a plotting command such as `plot3d` is given, the output appears in a separate window. When you have produced a plot that you would like to paste into your Maple worksheet, move the mouse to the plot window and choose **Copy** from the **Edit** menu. Then click the mouse at the position in your worksheet where you wish to insert the plot and choose **Paste** from the **Edit** menu. A copy of your plot should now appear in your worksheet.

To insert text, such as a label for a plot, into your worksheet, click the mouse at the beginning or end of the plot and choose **Insert Text** from the **Edit** menu. Now type your label. To continue using your worksheet, choose **Insert Separator Line** and then **Insert Prompt** from the **Edit** menu. To remove the plot window from your screen, move the mouse to the plot window and choose **Exit** from the **File** menu.

Sometimes it is useful to be able to place a comment after a Maple command, rather than insert text elsewhere in the worksheet. To do this, enter the sharp symbol #. Everthing typed on a line following this symbol will be considered by Maple to be a comment, and therefore not executed.

To make your worksheet less cluttered, it is a good idea to have Maple suppress the output of various commands, e.g., the command `with(plots)` or a command given to assign a name to a plot. To do this, end the command with a colon (:), instead of a semicolon (;).

Printing your Maple Worksheet: To print your Maple worksheet, choose **Print** from the **File** menu. A panel will appear with the options "Output to File" and "Printer Command" at the top. Clicking on "Printer Command" directs your output to the printer, while clicking on "Output to File" places your output in a file, whose name is given in the adjacent box (the default is *session.ps*). If you wish to change this name, click in the box and type in a new name. Since the file will be a postscript file, the file name should have the form *something.ps*. When you have finished making your choices, click on the "OK" button.

Saving your Maple Worksheet: If your work is interrupted, you can save your work so that you can later resume where you left off. To save your Maple worksheet, choose **Save As** from the **File** menu. Then type the name of the file in which you wish to save your worksheet in the **Selection** box. The file name should have the form *something.ms*. Note that the current path is already in the **Selection** box. The filename you choose should be added at the end. After you have typed the filename, click on "Save" to save the file. Once you have named the worksheet and saved it in a file, you can save further changes by choosing **Save** from the **File** menu. Maple automatically keeps track of the filename.

Opening a Previously Saved Worksheet: To open a previously saved worksheet, choose **Open** from the **File** Menu. Then type the name of the file you wish to work on in the **Selection** box and click on "Load." In Maple, you can have only one worksheet open at a time, so be sure to save the worksheet you are presently working on, before opening another one.

Ending your Maple Session: To end your Maple session, choose **Exit** from the **File** menu. A box will open, reminding you that all unsaved work will be discarded. If you have saved what you need or wish to exit anyway, click on "Exit."

Useful Commands and Techniques: If Maple gets hung up in a calculation or is taking too long, click the mouse on **Interrupt**.

Any Maple command previously entered in your worksheet can be re-executed without retyping it in a new location. Simply move the mouse to the position of the command you wish to execute and hit the **Return** key.

It is often useful to be able to refer later to the result of a computation—the output of some command—in a simple way. To make this possible, simply assign the output of the command to a variable. For example, if you enter `a:= evalf(2*Pi);` then you can later square the result of `evalf(2*Pi);` by typing `a*a;` .

If you assign the name `a` as above, and then continue your Maple session, you may want to reassign the name `a` to another expression. To do so, first unassign `a` by typing `a:='a';` . To clear all the assigned variables in a Maple session, type `restart;` . One common problem is to try to use such a variable without unassigning it, forgetting that is has already been assigned a value. A simple way to avoid this is to issue the `restart` command before beginning a new problem. This will not change anything on your screen.

Getting Help From Other Students:

The purpose of the Maple assignments is partly to learn about Maple, a very useful program for symbolic, numerical, and graphical computations, and partly to help you understand the material in the course. Just as with other homework assignments, it is permissible and helpful to discuss the Maple labs with other students. However, the Maple labs you are turning in are being graded and will be part of your final course grade. It is therefore expected that the work you hand in is your own in the sense that you have personally input everything that appears on your Maple worksheet, using notation that you have determined, in a style and layout that is your own, and with text comments that reflect the way you finally understand what is being asked. In light of the above, it seems highly unlikely that any two students would turn in nearly identical asssignments, and if such an event occurs, the students involved would be considered in violation of the policy on academic integrity and subject to university sanctions.