Instructions for Use of Maple in Mathematics 251

Fall 2005

This document These instructions are made available in two formats with the same contents. A printed version is distributed at the meeting in the **IML** during a recitation period early in the term, and a **PDF** version is available from the course web page:

`http://www.math.rutgers.edu/courses/251/`

Why use Maple The purpose of the Maple assignments is partly to learn about Maple, a powerful and very useful program for symbolic, numerical, and graphical computations, and partly to help you understand the material in the course. Rutgers has a license that allows Maple to be available on many systems, including **eden**, the **PC labs**, and **departmental networks**.

Aside from the required use of Maple in lab projects, there are other ways that this program may prove valuable. It is an important part of this course because it can graph curves and surfaces in three dimensions, solve complicated systems of equations, and perform all of the differentiation and integration operations met in this course. The **Student package** allows you to examine the steps of many of these operations (through Calculus I in Maple9, but a Multivariate Calculus package was added to Maple9.5). This package may be useful in checking your homework and preparing for exams.

The current version of Maple is **Maple10**, which was released in the summer of 2005. It is expected that this version will be available in the student labs, but new features will not be a **required** part of the projects in this course. Version 9 (released in 2003) or 9.5 (released in 2004) should give equivalent results.

The history of Maple Maple has been around for a long time. The symbolic computation engine at the heart of the program was developed before the graphical interface that dominates present-day computing, and this text-based interface continues to be available. A graphical worksheet for a variety of platforms was introduced in one of the five releases of MapleV. This worksheet, identified by a **mws** extension, can still be used, but Maple9 introduced a new worksheet format, identified by a **mw** extension, based on **XML** and **Java**. These fundamental changes are important enough that only the new worksheet format will be used in this course.

The interface to support this format also led to a vast improvement in access to help pages as you work in Maple, and the help can be found just where you expect it on the menu bar of the application window. It is expected that you will consult the help pages as you work through the projects. In particular, many of those pages contain examples of the use of Maple commands that will be useful in writing those commands in the form that you want.

A new trend is an attempt to make Maple look more like standard mathematical notation. Mathematicians have long used a two-dimensional approach to describing their subject. One of the earliest uses of the graphical interface in Maple was to mimic this notation when showing the **results** of its work. Recently, there have been steps to allow users to present their **input** in a similar notation. The "document mode" introduced in Maple 10 further blurs the distinction between input and output with the goal of producing a neat report that hides the effort to coax the Maple kernel to do the required computations. While you may find this useful in other work, it is more useful when **learning** Maple to use the precise one-dimensional mark-up language having its roots in the command line interface. Although mark-up languages often look clumsy, they are **unambiguous**, so correct input leads to correct output. In the two-dimensional format, things that look the same can be different. For example, `exp(x)` and `e^x` are both shown as e^x, but only the former behaves correctly. This can even confuse Maple! Converting from a two-dimensional format to traditional Maple input will give the latter expression, although the former is usually intended.

A product named GiNaC (see http://www.ginac.de/) has this to say about the shortcomings of Computer Algebra Systems — in particular Maple: "First of all: Maple is a wonderful product. Yes, it is. However, when you start writing large-scale applications you are doomed to run into trouble with it unless you are extremely careful and know exactly what you are doing. One important problem with Maple (and any other CAS) is the lack of a standardized up-to-date language. For instance, the concept of Object Oriented design is not present. Quite generally, facilities for encapsulation are poorly developed. Maple's language is dynamically scoped and from time to time you find that Maple's developers messed up with that by not properly declaring variables to be local resulting in obscure (history-dependent) bugs. How are we supposed to write scientific software with the language even the Maple developers have problems to handle? Mathematica and Macsyma face the same problem, by the way."

It continues: "Rather than pointing out a number of Maple's linguistical and structural weaknesses let us ponder about one simple fact. The purpose of symbolic computation is to *simplify* mathematical expressions so that we can more easily understand their structure or code them more efficiently for numerical evaluation by a computing machine. Most beginners simply use their Computer Algebra tool by typing in some expression and then tell the system to *simplify* it, usually by a command with that name. This is fine, so far. However, when several people embark on a large-scale project that relies considerably on symbolic computation, it is unacceptable. This is because whenever somebody codes simplify(expression) somewhere, this is a demonstration of his inability to understand what's going on. Does he really want to *simplify* a rational function by canceling a greatest common divisor from numerator and denominator? Or maybe he really only wants to expand an expression and later collect for some variable? When the CAS manufacturer ships the next release of his product, such calls to "simplify" are doomed to break. Sure, CAS do an amazing job at simplifying results. But since nobody ever defined what *simple* really means the next release might come up with different (though still hopefully correct) results. This frequently leads to subtle errors that are very hard to debug. When you start a large-scale program involving Computer Algebra, it is a good idea to memorize this: **simplify is evil**."

We will give other examples of some expressions that need to be given in a special form, while the way you have been writing mathematics will be considered to be an error. In Maple 10, there has been some attempt to understand traditional input, but this is new and may not always work correctly.

Getting started

The student labs should all have Maple10, but Maple 9 or 9.5 should work equally well for all projects. On Unix systems, like eden, the graphical version is called **xmaple**, since it is customized to run under the X windows system. Since there are no longer X-terminals in the student labs, most work will be done on PCs where all versions of Maple are usually installed on the "Course Related Software" section of the *Start Menu*. It is also expected that the Microsoft Windows desktop on the lab PCs will be taught to recognize Maple worksheets so that you can start Maple by selecting the file that you want to open. The commands you use to do mathematics with Maple will be the same on all these machines, although there may be differences in the way that files are opened, saved, and printed. The **Tools** menu includes a **Options** item to change the appearance of Maple. Since other users of the lab machines may have different preferences, you should learn how to use this to make sure that you will be working in **Worksheet mode** (not the "Document Mode" introduced in Maple 10) with **Maple input** (not any form of 2-D input).

It is important that you be able to save worksheets to allow editing of your initial results. The best place to save worksheets is in your eden directory. The standard way to do this is *WebDrive*. This mounts a copy of your eden directory as a Windows drive (usually X:) and saves changes when you are ready to logout. In addition, direct access to a **special subdirectory** of your eden directory is available by **Remote Drive Mapping** using *Samba*, but this requires some advance planning and an extra password (see http://www.eden.rutgers.edu/tools.php).

Starting with Maple 9, each worksheet opens in its own window with a **Menu Bar**, consisting of a row of **menu buttons** (**File, Edit** etc.) at the top of the window. Underneath the row of menu buttons is the

Tool Bar, most of which are shortcuts to menu commands. Directly below the Tool Bar is the **Context Bar**, which consists of more buttons that are shortcuts to menu commands. If you have enabled **Tool Tips** from the **Interface** page of the **Options** notebook accessible from the **Tools** menu, when you place the mouse pointer on any of these buttons, a rough idea of what the button does will appear. The rest of the window, except for a small **Status Bar** at the bottom, is devoted to the worksheet. You can now give an instruction to Maple by placing the mouse pointer on the worksheet (just to the right of the prompt >), typing a Maple command, and then 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 each Maple command ends with a semicolon (if you forget the semicolon, Maple will remind you) or a colon. Both the colon and semicolon mark the end of a command. Usually the semicolon is used since this shows the output of the command; the colon suppresses output in cases where it would clutter the worksheet.

If you select part of the worksheet, the right mouse button brings up a **Context menu** that can be useful in editing the worksheet.

In order to guard against computer problems, you should save your worksheets often. Clicking on the **diskette icon** on the **Tool Bar** of your Maple window is a convenient way to save the current worksheet. You can also enable **Auto Save** from the **General** page of the **Options** notebook.

You can open several worksheets in the same Maple session. Prior to Maple9, the standard behavior was for all worksheets in a session to share the same Maple kernel so that instructions in one worksheet would be known to all worksheets in that session. This could be confusing, so older projects were designed to be done in a single worksheet. Maple9 changed the standard to confine the effect of instructions to the worksheet in which they are entered. This is known as the **parallel kernel mode**. The setting may be checked (or changed) on the **General** page of the **Options** notebook. To take better advantage of the parallel kernel mode, the idea of a **Supplementary Worksheet** was introduced into course projects in Fall 2004. Now, you will work with two worksheets: one that starts from the **Seed File** and contains work that you will submit for grading; and one **Supplementary Worksheet** for following suggestions and testing options when constructing plots.

If you assign the result of a Maple computation to a name, that name will refer to that value for the rest of your Maple session unless you make another assignment to that name or use the `restart;` command. Erasing the instruction from the worksheet will **not** remove its effect. Also, only the **order of executing** instructions, **not the position of the instructions in the worksheet** affects the values of named variables.

On the other hand, it is usually the case that, if you open a previously saved worksheet, **none of the results** of that worksheet are known, even though they are visible in the worksheet. (This is changing: Maple 10 introduces the ability to **Auto-Execute** parts of the worksheet to assure that important commands are executed at the start of each session. This feature is so new that its use cannot be described here.) Your new session will learn those results by executing the instructions, either one at a time by hitting the **Enter key** on each line, are all at once using the **Execute. . . Worksheet** item in the **Edit Menu** or the **!!!** tool on the toolbar. This step is also useful to check that results in your worksheet appear in the same order as the instructions. **This consistency is expected in the printed worksheets that you submit.**

Getting Help from Maple Since you will not be given a Maple manual, you should learn to use Maple by using the built in **Help** facility. There is a **Help Menu** at the right end of the menu bar. Selecting any of the items in this menu will open the **Help Browser Wind ow** (introduced in Maple 9 — a less convenient set of help window were used in earlier versions). New users are presented with this **Help Browser Window** when Maple starts. The menu also identified **Keyboard Shortcuts** that will help you get the help you want quickly. You should learn these shortcuts.

Only one Help page at a time will be visible, but the browser includes a **History** panel as well as an **index** and a **search tool**. The help pages give the **exact syntax** of Maple instructions and **examples of their use**. It is expected that you will refer to this help to get the exact format of some instructions named in the projects.

The **Help Browser** also contains pointers to **Example Worksheets**. One such, named **Basic How To** introduces some frequently used Maple commands. The help menu also identifies **Keyboard shortcuts** to quickly get the help you need.

Maple Worksheets

The window that 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. The printout should include only the numerical, symbolic, and graphical output of Maple that is appropriate for the solution of the problems assigned, plus **text material interpreting the results** obtained by Maple. Using the **T** tool will insert a new line into the worksheet in text mode, allowing descriptive material to be added. (**Undocumented Feature**: Prior to Maple 9, this tool modified the current line, but this change is not described in the documentation.) To modify the mode of the current line, use the **Convert to** submenu of the **Format** menu. The **Insert** menu also contains items that modify the current line. Its **Execution Group** submenu may be used to add a line. This is the only way to add a line before the cursor, but lines are more easily added after the cursor using the [> tool on the toolbar. Text lines can also be used to label graphical output, but better results can be obtained using the **title option** in the plot instruction. Maple includes various editing capabilities that should enable you to produce neat and coherent output, 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. The region should now be highlighted. The **Delete** key will purge what you have selected. A safer approach is to choose **Cut** from the **Edit** menu or toolbar. This allows you to copy the removed region to a new location by selecting **Paste** from the **Edit** menu or toolbar. There is also a **Copy** tool, and an item in the **Edit** menu, that makes a region available for pasting without removing it from the worksheet. These operations are borrowed from your computer's *Window Manager*, so it should be possible to copy parts of your Maple worksheet to other applications. You can also delete whole lines with the *Ctrl-Delete* key combination. You should experiment with the different aspects of the user interface (mouse, keyboard, menu or toolbar items) to find the method that you find easiest for customizing the appearance of your worksheet. When text is highlighted, the right mouse button brings up a **Context Menu** that contains the commands from the Edit 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 #. Everything 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 (;).

Obtaining the Labs in Worksheet Form

In some of the labs, part of the lab will ask you to execute a string of Maple commands to learn what they do. To avoid retyping these commands, you can first obtain a modified copy of the lab in worksheet form (a "seed file") from the course web page. These seed files have now become an essential part of these lab projects, since some sample Maple instructions appear only in the seed file.

A change made during the Fall 2004 semester is the use of a **Supplementary Worksheet** for work related to a project that should not appear in the final report. Because this will contain important clues, this worksheet should also be obtained before starting your work. The **parallel kernel mode** keeps the work in these two worksheets separate, but you can copy instructions from one worksheet to the other.

Opening an Existing Worksheet File managers should be configured to start Maple when you activate the icon of a worksheet file. To open an existing worksheet while Maple is running, you can choose **Open** from the **File** Menu or the toolbar. A dialog box will be shown. Navigate in that box to the correct directory and select the name of the file you wish to open and then click on the **Open** button at the bottom of the box.

Arithmetic The operations **addition**, **subtraction**, **multiplication**, and **division** are indicated by `+, -, *, /` respectively. Fractions are represented exactly, and Maple automatically reduces them to lowest terms. Thus, if you type `1/3+1/6;` , Maple will answer 1/2. Exponentiation is also available with the operator `^`, but it should be used **sparingly**. Many expressions that we write using exponents are better described using the **exponential function** described in a later section. If you select e^a from a palette when input is set the **Maple Input**, you will get the correct expression `exp(a)`.

When operating on integers or fractions, Maple will do **exact arithmetic**, rather than using decimal approximations. To get a decimal approximation, use the Maple command `evalf`. The Maple command `evalf(4/7);` produces a 10 digit approximation to 4/7—as will typing `4.0/7.0;` . Additional accuracy can be obtained by including a modifier: typing `evalf[20](4/7);` will produce a 20 digit approximation. (Note: this form of the `evalf` function is now standard, replacing an older form `evalf(4/7,20);`. The older form is still accepted, but no longer described in the *Help* file.) You can also change precision for your whole Maple session by setting a new value to the reserved variable `Digits`. Selecting the output of an exact computation will allow some conversions to be made by using the right mouse button to get a context menu.

Algebra **All** grouping of expressions is done with the left and right parentheses — "(" and ")" — since other types of brackets have special meaning. Although the usual rules of precedence apply, you can **always** use parentheses to clarify your intent. Variables are not limited to single letter names, as in Elementary Algebra (and most Calculus texts). You can use (almost) any string of letters and numbers that starts with a letter to name a variable. As a result, the **product** xy **must** be written `x*y`, not `xy` or `x y`; if you type `xy`, Maple will assume you are referring to a variable called "`xy`". Thus, to enter the expression $(2x + y^2)/(x^2 + y) + 1$ into Maple, you type:

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

Recent versions of Maple allow you to use a **palette** (which is available from the **View** menu, or as a part of a **sidebar**) to help build expressions. This will give the correct form of the expression for the selected input mode. It can help translate the standard mathematical notation in project descriptions into **Maple input** in your worksheet.

To help you do algebraic manipulations, Maple has the commands `expand`, `factor`, and `simplify`, which you can learn about by using the **Help** facility. It is often necessary to `expand` an expression before Maple will know what it means to `simplify` it. In particular, Maple considers

```
(2*x +y)*(x + 2*y);
```

to be simple. Likewise, after you `expand` this expression, Maple will consider the expanded form to be simple, but the `factor` command can be used to return the factored form.

Algebraic numbers like $\sqrt{2}$ are considered to be exact quantities. If you enter

```
a:=(sqrt(2)+1)^10;
```

Maple will appear to simply echo a **prettyprint** version of that statement.

To get an answer in the form $3363 + 2378 * \sqrt{2}$, follow this line with `expand(a);` .

You can also solve algebraic equations using the commands `solve` (for exact answers) or `fsolve` (for numerical answers to the accuracy specified by `Digits`).

The standard functions

Note that the exponential function is built into Maple and is referred to as `exp`. The number e, if you ever need it, is `exp(1)`. If you have the fragment `e^x` in a worksheet, it will **look** right, but will usually give **incorrect results** when you try to **use** it. Similarly, the number π has the special name `Pi` — **not** `pi` that looks the same in output lines, but will be treated as an ordinary variable (this may change in future releases, but it is still correct in Maple 10). If you want to, you can say `pi:=3;` but this won't affect the value of π or anything that depends on it. However, Maple will fuss at you if you try to change the value of `Pi`. Except for `Pi`, that has been part of Maple for a long time, other names that are Greek letters — upper or lower case — are shown as that letter in output. This can be confusing in cases like `Mu` where the Greek letter **looks like** a related Latin letter. Maple also recognizes names like `log`, `ln`, `sin`, `cos`, `tan` as standard functions. Those names are also protected against use as names of variables. Normally, `log` is treated as a synonym for `ln` — to get the *common logarithm* of 2 that your calculator uses, you should write `log10(2.);` or `log[10](2.);`. The instruction, `FunctionAdvisor(known_functions);` will give you a list of names of the functions that are available. Many of these have unfamiliar names since they are defined in advanced mathematics, but you should recognize all the **elementary functions** that you learned how to differentiate in CalculusI.

User-defined Functions and Expressions

In Maple, `x^2 - 2*x +3` is an **expression**. You can use a name to refer to this expression for future use by typing `g:= x^2 - 2*x +3;` . Note that **a colon is required before the equal sign** in an **assignment statement**. Expressions can contain several variables, as in `h:= y*t - sin(y)`. To evaluate an expression at a particular value, use the Maple command `eval`. For example, `eval(g,x=2);` will produce the value 3. In many cases, the Maple command `subs` has a similar effect, although the order of the arguments is different. For example, `subs(x=2,g);` will also produce the value 3. If you decide to name something after you have evaluated it, the context menu for the result of the computation includes an option to assign to a name.

Maple also has a construct called a **function**, defined by statements like `f:=x -> x^2 - 2*x +3;` . This allows you to recover the expression $x^2 - 2*x + 3$ as `f(x);` , and to perform evaluation using the familiar notation `f(2);` . It is also possible to substitute expressions for x — even expressions that contain x — and get the result that you expect. For example, `f(x+1);` returns $(x+1)^2 - 2*x + 1$, which you could **expand** or **simplify** to get $x^2 + 2$.

We won't often use functions, except for pre-defined functions like `exp(x)` or `cos(x)`, since it is easier to work with expressions, but you might see them in examples on **Help** screens. Some *seed files* may also define functions to extend the Maple language on that worksheet. While we don't expect you to **write** functions in the Maple programming language, you should have no difficulty **reading** these definitions.

Plots

The basic graphing command in Maple is `plot`. This command has many forms—for example, several functions can be plotted at once—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 all but the most basic plotting tools you must first issue the command `with(plots);` to load a library of procedures written in the Maple language. For example, this is necessary in order to use the command `implicitplot`. You can also modify the style of the plot using the Control bar or **context menu** (obtained by clicking the right mouse button near the plot). These changes will lead to a plot with features **not shown in the instruction** that drew the original plot. One of the main uses of the supplementary worksheet will be to **experiment** with plots and determine the options that give the plot that you want. When you have determined all options, write the complete plot command at a > prompt in your main worksheet. Then, the plot will be drawn the same way every time that worksheet is executed.

When viewing three dimensional plots, it is useful to view the plot from different viewpoints. First, place a box around the plot by moving the mouse pointer in the region occupied by the plot and clicking the left mouse button. Now, place the mouse pointer inside the box and while holding down the left mouse button, move the mouse pointer to different positions. You should also explore the effects of using the **Axes** and other commands.

A **PlotBuilder** was introduce in Maple 9. It has been modified in subsequent releases, so now it is mostly useful for producing one plot or a single instruction for drawing it.

Vectors

As of Maple6, Maple now has two different packages for linear algebra. These packages allow powerful operations to be introduced simple by calling them by name. The original `linalg` package imposed a complicated structure on everything it touched. As a result, simple things became more difficult. The newer `LinearAlgebra` package is easier to use and is the basis of a `VectorCalculus` package that allows you to communicate to Maple using the terminology introduced in this course.

Calculus

In addition to performing basic calculations and evaluating expressions containing standard functions, Maple can also differentiate and integrate. The `diff` command differentiates **expressions**. For example, `diff(x*sin(x), x);` differentiates $x\sin(x)$ with respect to x. If you have named an expression, it is a useful convention to introduce a modification of that name as a name for the derivative (or partial derivatives). That is, if you have `y:=x*sin(x);`, you can write `y1:=diff(y,x);`. A second derivative can then be found, and named, by writing `y2:=diff(y1,x);` to differentiate the first derivative using the name that you introduced. If you need a second derivative without seeing the first derivative, either `diff(x*sin(x), x, x);` or `diff(x*sin(x),x$2);` may be used. If you have typed `g:=x^2*y;` , then `diff(g,x);` gives the first partial derivative of x^2y with respect to x and `diff(g,x,y);` is the mixed second partial derivative. It is also possible to differentiate **functions**, but this uses a **totally different** set of conventions.

Note that Maple assumes that everything not involving the variable with which it is differentiating is constant. This means that **no special notation** is required to distinguish partial derivatives of expressions from ordinary derivatives. Note that, although we claim to be differentiating **functions** in Calculus, the techniques are based on examining how **variables** appear in **expressions**, so the way that Maple works with expressions is more familiar.

The command for both definite and indefinite integration is `int`. If Maple cannot evaluate a definite integral exactly, numerical integration may be used. Definite integrals are evaluated using a single instruction written like `int( sin(x), x=0..Pi );` to get

$$\int_0^{\pi} \sin x \, dx.$$

It is not necessary to apply either the `subs` or `eval` instruction to the result of indefinite integration, although that approach gives the same answer. The role of dx in the mathematical notation for integrals is played by **including the name** of the variable x in the second argument of the `int` instruction.

The `VectorCalculus` package includes commands to work with the extend forms of differentiation and integration introduced later in this course.

Maple9 also includes a package named `Student[Calculus1]` that you can use to review basic calculus. There are **interactive** worksheets that allow you to practice the techniques of basic calculus and to step through the solution of problems. The **help pages** will guide you in the use of this package.

Printing your Maple Worksheet.

The projects in this course are to be submitted as **printed worksheets**. Usually, two weeks are allowed from the time the project is assigned until the printed worksheet is due. This allows you to explore different approaches to the project and to edit your results.

To print a Maple worksheet, choose **Print** from the **File** menu or click on the print button in the **Tool Bar** (its position varies, but it is with the other file tools at the left and its icon looks like a printer). A panel will appear with the options "Output to File" and "Print Command" at the top. Clicking on "Print Command" will direct your output to the printer if the command has been correctly entered, while clicking on "Output to File" places your output in a file, whose name and location will be chosen in another dialog box (the default is *out.ps*). If you wish to change the file name or the print command, click in the box and type your changes. Since the file will be a postscript file, the file name should have a **ps** extension. When you have finished making your choices, click on the "Print" button.

You should also use the following tools to improve the appearance of your printed worksheet.

(1) **Print Preview** to see how your worksheet will appear before you commit it to paper.

(2) The **page break** item in the **Insert** Menu to force extra page breaks as needed to improve readability. In Maple 9 the location of the break is shown in the worksheet on your screen.

Saving your Maple Worksheet. If your work is interrupted, you can save your work so that you can resume later where you left off. There is a tool on the toolbar that saves a worksheet under its current name if it has one, or prompts you for a place to save a newly created worksheet. In addition, the **File** menu contains the usual **Save** and **Save As** options. The **mw** extension will be added to the name that you give.

It is also possible to save the file in the older **mws** format, but this may lose features introduced after Maple8. **Don't do this unless absolutely necessary**, and inform your instructor if you will not be able to complete the worksheet in Maple9 (or newer).

Ending your Maple Session To end your Maple session, choose **Exit** from the **File** menu. When you close a worksheet, or exit the program, Maple will prompt you to save worksheets that have changed since the last save. This may only save the worksheet of the PC in the lab. That file will then need to be copied to your directory on eden to have it available for later editing. (although both **WebDrive** and **Samba** should do this automatically)

Useful Commands and Techniques. If Maple gets hung up in a calculation or is taking too long, click the mouse on the **stop** button in the **Tool Bar** menu. This usually means that the command that Maple was working on was incorrect. An **alternative approach** to the calculation may give the desired result. Computational efficiency is usually not an issue on modern computers, so you shouldn't try to find the best way to compute something. However, you should check that reasonable results are obtained fairly quickly.

Any Maple command previously entered in your worksheet can be re-executed without retyping it in a new location. Simply move to the position of the command you wish to execute with the mouse and hit the **Enter** (or **Return**) key. However, this works **only for the current session**. If you need the instruction at a different point in the worksheet, it should be moved or copied there.

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;` . It you find that you need a recent result that was not named, the special names `%, %%`, etc. may be used to refer to the previous result, the one before that, etc. (the instructions are not clear about how much of the history can be retrieved in this way). Maple 10 introduced **line numbers** for output. These can be used via a **context menu** to insert previous results in new commands. A better solution might be to add a name for the result on the line that computed the expression and re-execute that line. This effect can also be obtained with a context menu.

You can assign a name to a plot just as described above for assigning a name to an expression, but an instruction creating a **named plot** should always end with a colon instead of a semicolon — you **don't want to see** that output. A single named plot can be viewed by entering the name of the plot followed by a semicolon on an input line, and several previously named plots can then be displayed on the same graph by using the command `display`. This is part of the `plots` library. Looking in the documentation for that library may be the easiest way to find the help page for this function.

Only the most recent assignment to a name is remembered. You can unassign `a` by typing `a:='a';` . To clear all the assigned variables in a Maple session, you can type `restart;` as indicated earlier. If you are unsure of what value has been assigned to the name `a`, you can type `a;` at the current prompt. Such working notes should be edited out of the main worksheet before you submit it.

Getting Help From Other Students The course includes some **laboratory projects** that form a small portion of your grade. Just as with other homework assignments, it is permissible and helpful to discuss these Maple labs with other students. However, the Maple lab reports that you turn in are being graded and will be part of your final course grade. As with all such work, the printed form of the worksheet is expected to be the work of the student who submits it. In particular, the projects include questions that involve your interpretation of results of Maple's computation. The grader will concentrate on the text comments that contain your answers to these questions. These comments are expected to reflect your **individual understanding** of the topic and the grader will notice when several students submit nearly identical statements..

End of Maple instructions document