Mathematics 41, section 1 – Analysis 3
Lab Day 1 – Getting Acquainted With Sun/Unix, 3D Plotting
September 15, 1999

There is additional information about Maple commands, etc. in the Damiano and Freije *Collaborative Learning Manual*. You will probably want to consult that in addition to the information here, especially on later lab assignments. Some general information about the Unix operating system is available from a link on the course homepage.

Running Maple in SW 219

The machines in SW 219 are powerful Sun workstations. The operating system running on them is called *Unix*. Unix is the operating system of choice for many mathematicians and most computer scientists for their own work. It was designed from the start with networks in mind, so it is generally much more reliable than the Microsoft Windows 95, 98, and NT operating systems commonly used on PC's. There is also a version of Unix called *Linux* that is available (free) for PC's. Depending who you listen to, Linux/Unix may be the "wave of the future" on PC's too!

To run Maple on the Sun workstation network:

1) Log onto any machine using the username/password (Note: this is *not* your campus network username/password). The Sun workstation network is connected to, but separate from, the rest of the campus network.
2) Open a *Terminal* window using the Workspace Menu (to get this place the cursor over the desktop background and press the *right* mouse button),
3) Type in `xmaple &` at the command prompt (the computer name, followed the % sign) in the Terminal window.

(The `xmaple` part should be more or less self-explanatory; the ampersand `&` means that Maple will be run in an independent window, and the Terminal window will be available for you to input additional commands, etc. If you omit the ampersand, the Terminal is not usable this way while Maple is running.) Take a moment to look over the Maple window and note its features. (If you have used Maple in the HA 408 PC lab, you will see that this user interface is almost exactly the same.) The "subwindow" marked Untitled (1) opened inside it is a blank *Maple worksheet*.

Maple Worksheets

Worksheets are integrated text/graphics/mathematics documents where any or all of the following can be done:

a) you can type in commands from the keyboard to ask Maple to perform many different kinds of calculations, read data from external files, store work in files, etc.
b) output generated by Maple from your input commands (numerical values, symbolic formulas, and graphics) will be displayed,

c) you can modify commands, generating new output, store your results for use later, etc.

d) you can enter text to annotate and explain the results of computations.

Much of your interactive "management" of a worksheet in progress will take place through the File, Edit, View, Insert, etc. pull-down menus across the top of the Maple window, the "tool bar" below that with the button icons for various operations (can you guess what each of them does?), and the "scroll bar" on the right that you can use to move around within the worksheet, to see previous input and output lines, etc. Most of the common operations appear both as items in one of the pull-down menus and as toolbar buttons. The toolbar buttons are faster to use, but somewhat limited in the options they offer, so you will want to have a general idea what is accessible from where in the pull-down menus also.

Input and Text Regions in a Worksheet

A new worksheet window will be labeled something like Untitled (1). On the first line of the worksheet, there is a [> in black. This is the Maple *input prompt* – the signal that Maple is ready to accept a command from you and try to execute it. A new input prompt will be generated automatically in a worksheet each time you enter a command and execute it *at the end of a worksheet in progress*. You can also go back and insert new commands and output at any point in a worksheet as follows. You can *insert an input prompt* and an input region at any point in the worksheet by placing the cursor at the desired location and pressing the toolbar button marked with [>. (After executing an inserted command like this, Maple will drop to the next input line, so to insert several input lines in the middle of a worksheet, you will need repeat the above.)

As we mentioned before, Maple worksheets can contain text as well as commands and output. To create a text region you can press the [> button above, then the button marked by a capital T (this changes the region into a text region). Any text can now be entered, and this will be treated as an "inert" comment. That is, it will appear as you enter it when you print out the worksheet, and it will not be treated as Maple input. After you create a text region, if you press the capital sigma (Σ) toolbar button with the cursor placed on that region, you can type in a Maple expression in input format, and have it displayed (in "inert" form) in usual mathematical notation (with raised exponents, no asterisks for multiplication, etc. This is sometimes useful for creating "pretty" worksheets!

Saving and Reloading your Maple Worksheets

When you begin working on a worksheet, you will usually want to *save your work* every once in a while in case you need more than one lab session to complete the work you are

1) Select the SAVE option from the FILE pull-down menu, or press the tool bar button that looks like a 3 1/2 "floppy" diskette.
2) If you are saving your work for the first time, you will see a SAVE AS dialog box. Go to the Filename box, and type in a name for the file where the worksheet will be

stored (any string of letters and digits – no spaces – is OK) type in a period after the file name you chose and then the "extension" *mws* might be something like *lab1.mws*. Then click the OK button to write the worksheet to the network drive. (You will only need to type the filename once in a session. Subsequent saves just update the file. To save the worksheet in a new file (for instance with a different name), use the SAVE AS option.)

3) On the Sun workstation network, worksheets are saved to your space on a shared network hard disk drive. You can access these again from any one of the workstations in SW 219, or any of the Sun workstations in the Math/CS department. *But note: This storage is separate from your p: drive on the campus network, and you will not be able to read files from your p: drive in SW 219.*
4) To update the worksheet further in a later session, you can read the worksheet back into Maple using the OPEN option from the FILE Menu, or the "open" toolbar button. Get into Maple as above, and select OPEN from the FILE Menu. Maple will prompt you as above for the name of the worksheet with a dialog box very like the SAVE AS box described above. Highlight the worksheet you want, and click OK. IMPORTANT NOTE: When you read a previously created worksheet into a new Maple session, you *have not actually executed any of the commands in it in the new session*. If you want to make use of any results in that worksheet, you will need to execute the commands again. In the EDIT pull-down menu, you will see an EXECUTE option that lets you recompute an entire worksheet or a section of one. RETURN on selected input lines to do the same thing.

Printing

To print a file in SW 219, use the printer toolbar icon. In the Printer Setup form, the settings will need one adjustment – make sure the Print Command button is depressed, and change the print command line in the box next to it to: `lp -d hso_219_hp4000`. (The characters after the o and the 9 are "underscores".) After you press Print, the output will be routed to the network printer in SW219 for you to pick up.

Getting Out

When you leave, quit the Maple window (FILE/EXIT). Then log out from the Sun network (either the Log Out option from the Workspace menu, or the EXIT button on the Workspace toolbar). DO NOT TURN THE WORKSTATION OFF. THESE ARE LEFT POWERED UP AT ALL TIMES.

A First (or New) Maple Command

Today, we will be using the `spacecurve` command in the `plots` package to draw line segments in 3D, using the vector form for lines we have discussed in class. Begin your Maple session by entering the command:

```
with(plots);
```

This loads a package of plotting routines, including the `spacecurve` command that you should see in the list of command names generated by the `with(plots);`.

The `spacecurve` command can be used to plot any parametric curve in $\mathbf{R}^3$. The format for the command is

```
spacecurve([x(t),y(t),z(t),t=a..b]);
```

where $x = x(t)$,$y = y(t)$,$z = z(t)$ are the parametric equations of the curve and the range of parameter values to be plotted is $a \le t \le b$. (Note the placement of the square brackets – the format here is not flexible!) For instance, try entering the input command

```
spacecurve([1-t,2*t,3-4*t,t=0..1]);
```

This plots the portion of the line through the point $P = (1, 0, 3)$ with direction vector $\vec{v} = (-1, 2, -4)$ for t in $[0, 1]$, since

$$(1, 0, 3) + t(-1, 2, -1) = (1 - t, 2t, 3 - 4t).$$

The asterisks in the components of the input above are Maple's symbol for multiplication. The are *not optional* – in any formula involving a product, you will need to put in the $*$ symbol explicitly.

Type in this command line (exactly as here) and press RETURN. If you make a typing mistake, Maple will let you know about it(!). Fortunately, if this happens, the whole command does *not* need to be re-entered. Just move the cursor arrow to the place on the input line you want to change, press the left mouse button, and edit the input as needed. Typing from the keyboard will *insert* new stuff at the cursor location; the DELETE and BACKSPACE keys will remove stuff (DELETE removes the character in front of the "insert point"; BACKSPACE removes the character in back). You can also move around on the input line with the arrow keys if more than one thing needs to be changed. When you think it is OK, press RETURN again to have Maple execute the command again. The first plot you see here will be rather uninformative. Fortunately, Maple also lets you add axes and look at a 3D plot from different viewpoints. Here's how:

1) Click the left mouse button once over the graph. This should bring up a "bounding box" for the graph with corners you can *drag and drop* with the mouse to resize the graph.
2) If you place the mouse over the graph now and hold the left button down, when you move the cursor, you should see a box rotating following the cursor position. Release the left mouse button when you get to the position you want.
3) If you click the right mouse button, you will bring up a menu containing the options `Redraw, Copy, Style, Axes, Color` and several others. Select `Axes, Normal` with the left mouse button. Then repeat clicking the right mouse button and select `Redraw`.

Practice a few times repositioning the viewpoint (rotating the viewing box) and redrawing the graph.

To draw several parametric curves in the same graph, you can include several curve specifications in the form `[x(t),y(t),z(t),t=a..b]` between curly braces `{,}`, separated by commas inside the parentheses for the `spacecurve` command.

Lab Exercise

The points $P = (0,0,0)$, $Q = (2,0,0)$, $R = (0,\sqrt{3},1)$, $S = (0,-1,\sqrt{3})$ are four corners of a cube in $\mathbf{R}^3$ with edges PQ, PR, and PS, because the vectors $\vec{u} = Q-P$, $\vec{v} = R-P$, $\vec{w} = S-P$ all have magnitude 2, and $\vec{u}\cdot\vec{v} = \vec{u}\cdot\vec{w} = \vec{v}\cdot\vec{w} = 0$. Your assignment, should you decide to accept it (just kidding!), is to create a picture of this cube by drawing the 12 edges together on the same set of axes in $\mathbf{R}^3$ (begin by drawing the line segments from P to Q, P to R, and P to S). Also give a full explanation how you found the other corners of the cube and the remaining segments. This can be done in a text region (see information above for how to insert text regions in a worksheet).

Assignment

For this lab, we will be doing *individual writeups* due Monday, September 20.