Lab 3: Surfaces

In this lab we investigate how *Mathematica* can graph functions of two variables. The graph of such a function is a surface. *Mathematica* has several ways of helping us visualize these surfaces.

Step 1

First you need to copy the Lab3 notebook into your own account. Select the **/math235/notebooks** directory as you did in Step 1 of Lab 2. Then drag[1] the mouse over the two file listings **Lab3.ma** and **Lab3.mb** in the third column to select them.

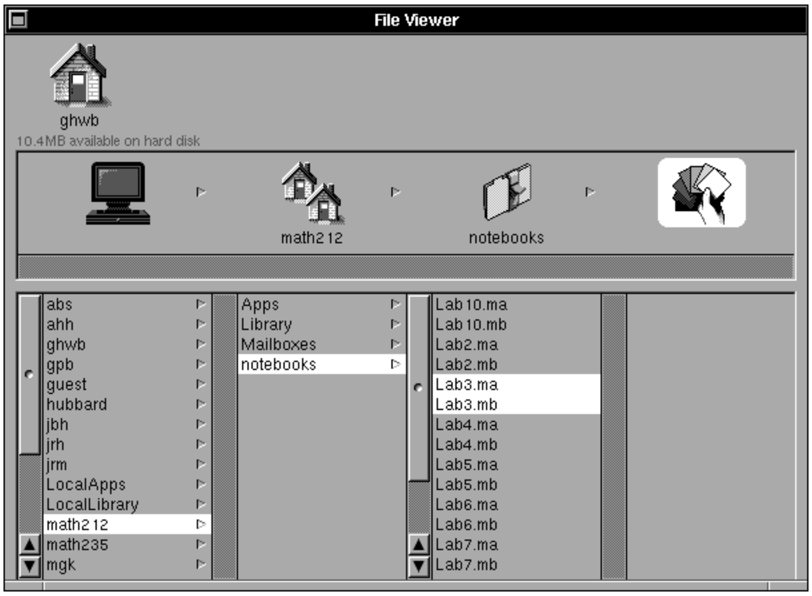

Figure 3.1 Selecting two files in **/math235/notebooks**

This causes the two file names to be highlighted, and a hand holding some cards appears over the fourth column. This card hand icon represents the two files selected.

Next drag the card hand up to the shelf [2] above it. This places a copy of the card hand on the shelf (Fig. 3.2).

[1] Recall that “dragging” the mouse means to move the pointer to one end of the region, hold the mouse button down while moving the pointer to the other end of the region, and then release the mouse button.

[2] Recall that the “shelf” is the top row of icons in the File Viewer (the row with the little house on the left). It is used to store icons of files that you want to access without having to search through the directory system.

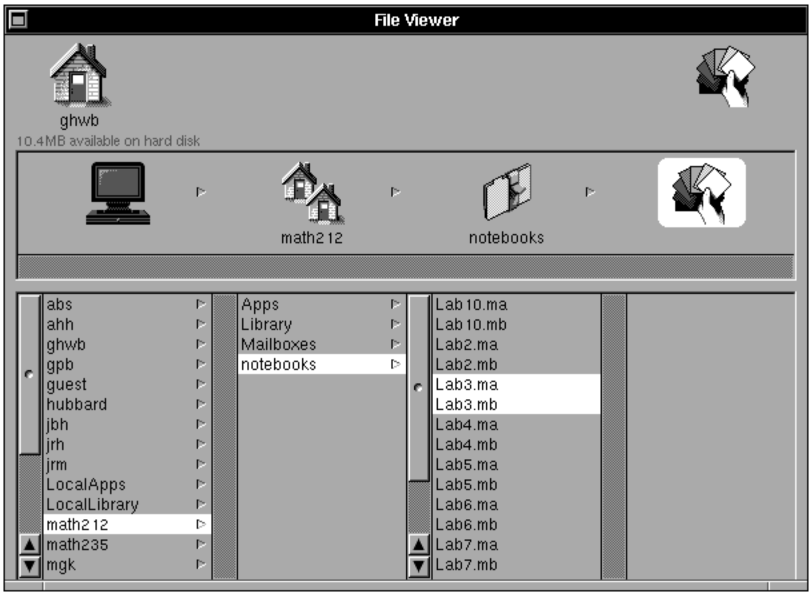

Figure 3.2 Placing a copy of the two files on the shelf

Now select your own **notebooks** directory, and drag the card hand icon down over the file folder icon labeled **notebooks**. This causes the file folder icon (which represents your **notebooks** directory) to open up. Then when you release the mouse button, it sucks the card hand icon in, and the two **Lab3** file names appear in the third column.

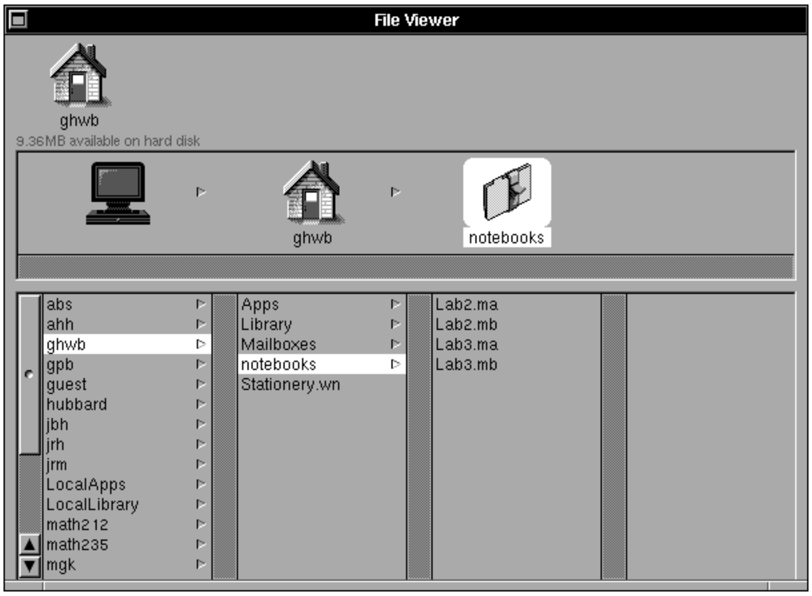

Figure 3.3 After copying the two files into /**ghwb**/**notebooks**

This is the standard method for copying and moving files on the NeXT. If you do this from one account to another, it will copy the files. If you do it between subdirectories in your own account, it will simply move the files without duplicating them.[3]

Step 2

Now open your copy of the **Lab3.ma** notebook[4] and then double-click on the main cell rectangle to view the three main sections of this lab.

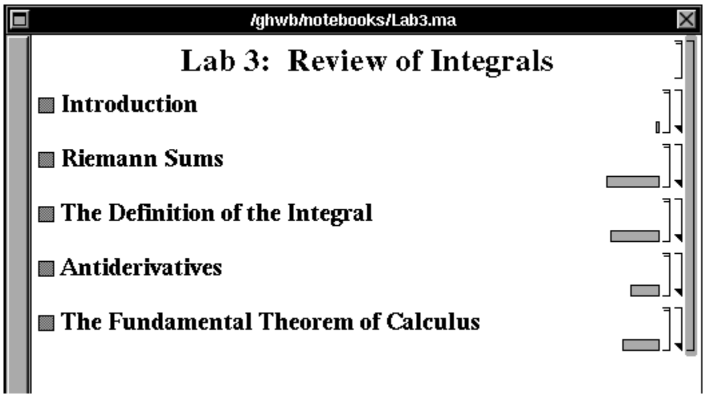

Figure 3.4 The main sections of **Lab3**

Begin working through this lab, just as you did Lab 2. Be sure to <u>open all subcells</u> and <u>execute all *Mathematica* commands</u> in the order in which they appear.

Work all the exercises, using the same *Mathematica* commands that are found in the notebook. (See the Appendix at the end of this handout for a summary of the commands that you will need.)

Go on to Step 3 after you have completed all the exercises.

Step 3

In the first two labs, you submitted your work by mailing a copy of your complete *Mathematica* notebook. This is rather inefficient because your own work comprises only a small part of the completed notebook. From now on, you will submit a separate lab report prepared with the *WriteNow* text processor.

To launch *WriteNow*, simply double-click on its icon (Fig 3.6) in the dock. Then click on the Document command in the WriteNow menu (Fig 3.7) to produce the Document submenu (Fig. 3.8). Click on its New command to produce a new *WriteNow* window (Fig. 3.9).

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[3] To *copy* files from one subdirectory to another in your own account, do the same think except hold the Alternate key down whijle you drag the icon into the file folder.

[4] Double-click on the **Lab3.ma** file name in the third column. If the *Mathematica* window is blank, click in it.

Figure 3.6 The *WriteNow* icon

Figure 3.7

Figure 3.8

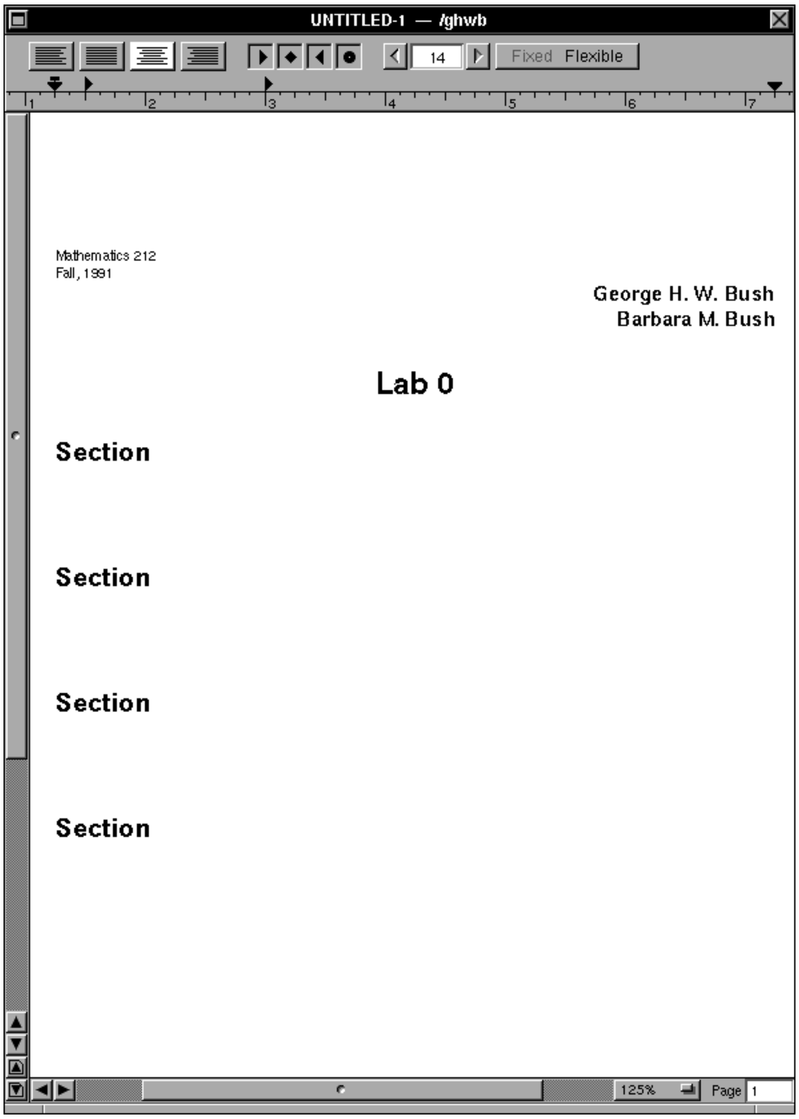

Figure 3.9 A new *WriteNow* window

It's usually best to save a new window immediately, even before you begin to write in it. Click on the Save As… command in the Document submenu.[5]

Figure 3.10

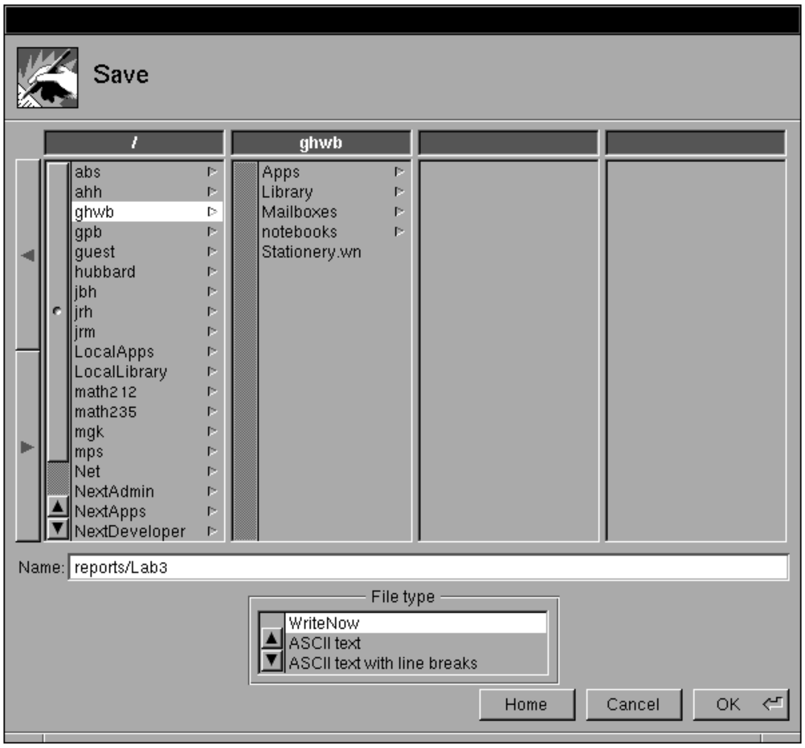

Figure 3.11 The **Save** panel

This brings up the Save panel. Type **reports/Lab3** in the text field labeled **Name:** and then press the Return key.[6] Since you are creating a new **reports** directory (for your lab reports), the NeXT responds with its Nonexistent path panel (Fig. 3.12). Press Return to acknowledge that you do want to create this new path. This saves your file in your new directory.

Now the title bar on your *WriteNow* window should read Lab3.wn — /ghwb/reports (except that your user name will be in place of the President's). Notice that you did not have to type the **.wn** It is the default, inserted automatically by *WriteNow*.[7]

[5] Compare Fig. 3.10 with Fig. 3.9. Most menus and submenus on the NeXT have some commands displayed in black and other commands displayed in gray. For example, the Save As… command is gray in Fig. 3.9 and black in Fig. 3.10. The gray commands are not selectable under the current conditions. For example, the Save As… command was not possible until after a new window had been created.

[6] Notice the button labeled OK at the bottom right of the Save panel. Next to the OK label is a curved arrow. That represents theReturn key. Most panels have a button with this symbol. It means that you can either click on the button with the mouse, or you can simply press the Return key on the leyboard. Among the various buttons, the one with the curved arrow is the *default*.

[7] Every system on the NeXT has its own *default file type*. It is **.wn** for *WriteNow* files. It is **.ma** for *Mathmematica* source files and **.mb** for the accompanying binary files.

Figure 3.12

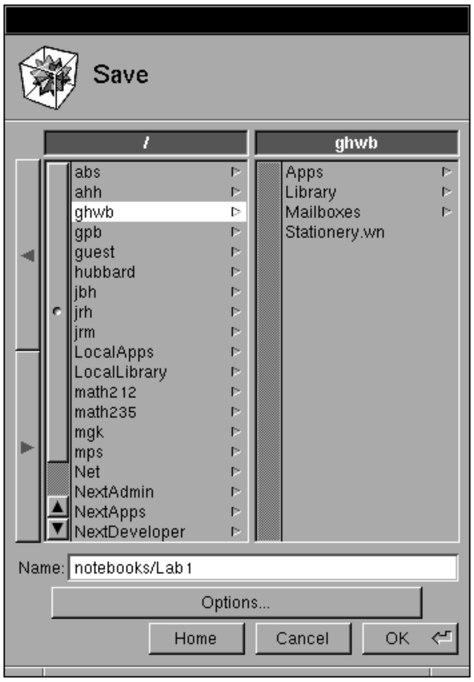

Figure 3.13

From now on, you can save your document simply by clicking on the little *save button* at the upper left corner of your window. Remember, when the little black X is complete, then the active document in your window is identical to the file saved on disk. But when the X appears with its center missing (as it will as soon as you begin typing in your window), then the active document in your window is different from the current version saved on disk. Prudent users save their work every 5 or 10 minutes.

Step 4

Now you're ready to begin writing your lab report. The first thing to do is to replace the existing names at the top with your name and your lab partner's name.

Use the mouse to move the pointer to the point just to the left of the G in George . Notice that when the pointer is over the *WriteNow* window it changes to a vertical I-beam. When you have the I-beam in position, drag the I-beam across to the right edge of the window and then down one line to the point just to the right of the h in Barbara M. Bush . This will cause that whole line and the right end of the one above it to become highlighted.

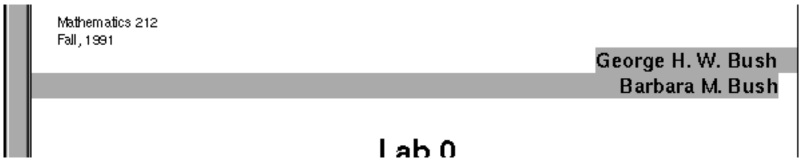

Figure 3.14 A selected block of text

A highlighted region like this is said to be *selected*. Selecting a block of text is a very common technique on the NeXT. It allows very efficient text processing.

Now to replace the Bushes' name with yours and your lab partner's, simply begin typing your name. As soon as you type the first letter, the selected block of text disappears. This is the standard way to replace a block of text.

After typing your name, press Return to type your lab partner's on the next line. Notice that both lines are *right-justified*.[8] That format is indicated by the *ruler*.

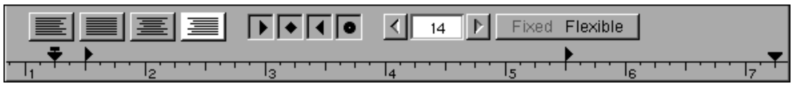

Figure 3.15 The ruler

The *ruler* consists of that part of the window's header that dies directly below its title bar. Among its several mechanisms is its set of *alignment buttons*. These are the 4 buttons at the left. Each is labeled with an icon of 7 horizontal lines, representing lines of text.

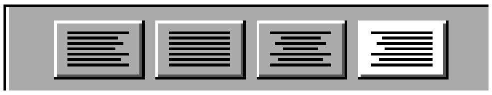
Figure 3.16 The four alignment buttons

Here, the fourth button is highlighted, indicating that this option has been selected. The four options are: left-justify, left-and-right-justify, center, and right-justify.[9]

Step 5

The report title also needs to be changed. To change the 0, move the I-beam directly over the 0 and then double-click on the mouse. This will select the 0.[10]

Figure 3.17 Selecting the 'word' 0

Now type **3: Surfaces** As soon as you type the first character, the **0** disappears and is replaced by whatever is typed.

[8] That means that the line are all alligned on the right edge of the window . Normally, text is left-justified.
[9] For more information on the many features of the *WriteNow* text processor, see Part 1 in the *Applications* manual, pages 3-79.
[10] This is a another method for selecting text: to select a single word (i.e. any sequence of characters not including spaces or punctuation marks), simply double-click on it.

Step 6

Now you are ready to begin writing your lab report. The purpose of the report is to describe what you learned from doing the lab. The style and organization that you use in writing the report is up to you and your lab partner. The important thing is to be clear and direct. Your grade will be based upon *what* you say— not *how* you say it. But do be consistent in your style, and take care to use correct spelling and grammar.

Your report should have three parts, one for each main section of Lab 3: **The Plot3D Command**, **Level Curves**, and **Density Plots**. In each part, describe what you learned. Use *Mathematica* wherever it helps. For example, your second section might look like this:[11]

> **Level Curves**
>
> A level curve is a curve is the intersection of a surface with a horizontal plane. The curve is projected down to the X-Y-plane. It gives a two-dimensional cross-section of the surface.
>
> The Mathematica command CountouPlot[f[x,y],{x,a,b},{y,c,d}] produces a set of level curves for the graph of the function f. For example: ContourPlot[x^2-y^2,{x,-2,2},{y,-2,2}]
> will show the level curves of the graph of z = x^2-y^2, in the range -2 ≤ x ≤ 2 and -2 ≤ y ≤ 2.
>
> Level curves can be used to locate maximum and minimum points on the surface.
>
> **Density Plots**

Figure 3.18 A lab report write-up on **Level Curves**

Step 7

Notice (Fig. 3.9) that your *WriteNow* file already has Section headings. The first thing to do then is change these to the actual heading for Lab3: **The Plot3D Command**, **Level Curves**, and **Density Plots**. Do this the same way you changed the Bushes' names: double click on the word Section, and then type its replacement.

Now click on the line below your Level Curves heading and begin typing. Skip a line wherever you want to include examples from *Mathematica*. After you have typed all the regular text for this section, you file should look something like Fig. 3.19.

Now activate your *Mathematica* window, and execute the following commands:

```
f[x_,y_] := Sin[x+Sin[y]];
f[x,y];
Plot3D[f[x,y],{x,0,4Pi},{y,0,4Pi},PlotPoints->32];
CountourPlot[f[x,y],{x,0,4Pi},{y,0,4Pi},PlotPoints->32]
```

[11] The ≤ symbol is produced with the Alternate key: Alternate-Shift-<

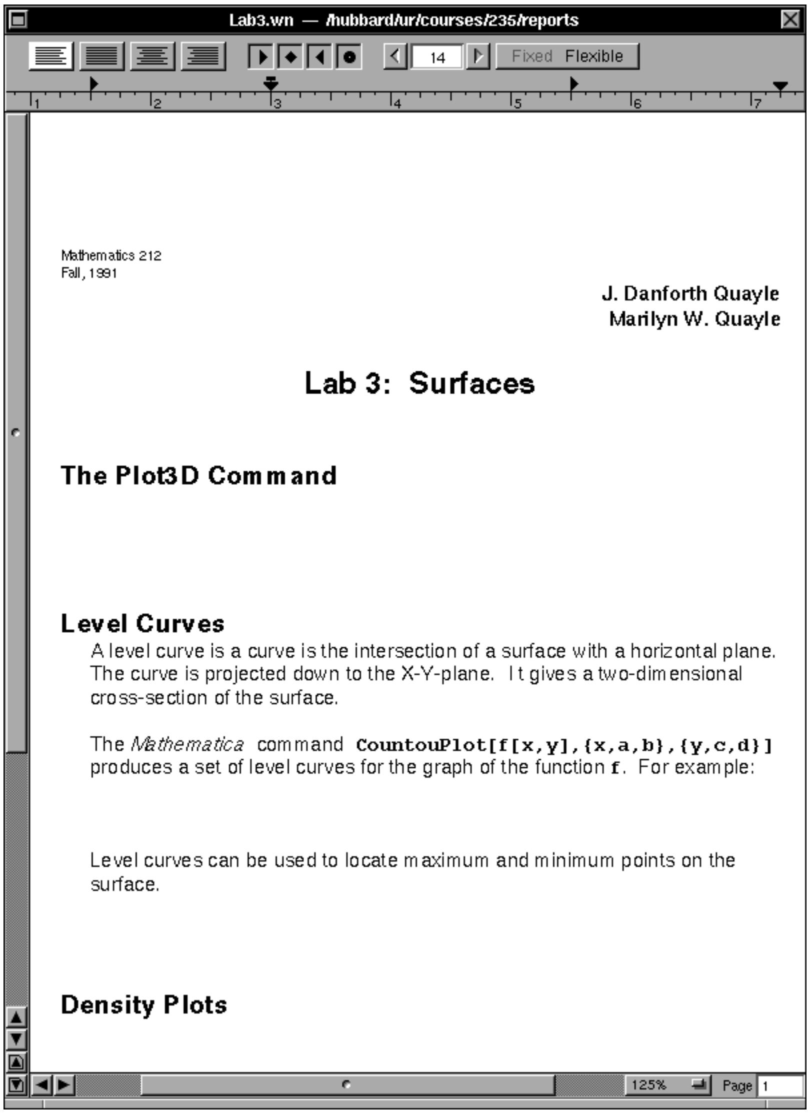

Figure 3.19 Before inserting *Mathematica* text

To copy this *Mathematica* input together with its output into your *WriteNow* file, click on the cell that contains the first line of input. Then hold the Shift key down and click on the cell that contains the last output. This click-Shift-click procedure is another way to select a block of text.

Now select the Edit command in the Mathematica menu, and then select the Copy command in the Edit submenu. This makes a copy of the selected *Mathematica* cells, and saves them in a special buffer called the *Pasteboard*. You can now “paste” these cells in other files.

■ **Examples**

Mathematica uses the ContourPlot command to draw level curves. Here's the contour plot of the third hyperbolic paraboloid shown in the previous section:

ContourPlot[x^2-y^2,{x,-2,2},{y,-2,2}]

All the curves shown here are hyperbolas. For example, the level curve at the level z=1 on the surface would have the equation x^2 - y^2 = 1. That is the inner-most

Figure 3.20 Selecting a *Mathematica* cell

To copy the cells into your *WriteNow* file, click on the *WriteNow* icon in the dock to activate your *WriteNow* window. Then click on the blank line to set the insertion point where you want to paste the cells. Then click on the Edit command in the WriteNow menu, and then click on the Paste command in the Edit submenu. The six *Mathematica* lines should appear in your *WriteNow* file.

Level Curves

A level curve is a curve is the intersection of a surface with a horizontal plane. The curve is projected down to the X-Y-plane. It gives a two-dimensional cross-section of the surface.

The Mathematica command CountouPlot[f[x,y],{x,a,b},{y,c,d}] produces a set of level curves for the graph of the function f. For example:
ContourPlot[x^2-y^2,{x,-2,2},{y,-2,2}]
will show the level curves of the graph of z = x^2-y^2, in the range -2 ≤ x ≤ 2 and -2 ≤ y ≤ 2.

Level curves can be used to locate maximum and minimum points on the surface.

Density Plots

Figure 3.21 After pasting the *Mathematica* lines

This Copy-Paste procedure from one window to another is a common activity on NeXT workstations. It works the same way with all software on the NeXT.

Step 8

After you finish writing your Lab report, mail it to **math235** the same way you mailed your *Mathematica* notebooks in Lab 1 and Lab 2: drag your report's file icon into your Send window.

Appendix: *Mathematica* Commands

Here are some of the *Mathematica* commands that are used in this lab:

`Plot3D[x-y,{x,0,2},{y,1,5}]`
Graphs the surface $z = x-y$ for $0 \leq x \leq 2$ and $1 \leq y \leq 5$.

`ContourPlot[x-y,{x,0,2},{y,1,5}]`
Graphs the level curves for the surface $z = x-y$ for $0 \leq x \leq 2$ and $1 \leq y \leq 5$.

`PlotPoints->32`
Increases the number of points plotted in each dimension from 14 to 32. This makes the surface smoother, but requires more time to generate it.

`f[x_,y_] := -4x/(3+x^2+y^2)`
Defines the function **`f[x,y]`**.

`DensityPlot[f[x,y],{x,0,2},{y,1,5}]`
Shows a direct top view of the surface **`z = f[x,y]`** for $0 \leq x \leq 2$ and $1 \leq y \leq 5$, with the highest points shaded the lightest and the lowest points shaded the darkest.

`Mesh->False`
Suppresses the display of the mesh lines, making the surface look smoother and more natural. The mesh lines show where certain vertical planes intersect the surface.