Lab 1: Graphs and Derivatives

In your Introductory Lab you learned how to use the NeXT workstation to solve simple problems with *Mathematica* and to submit your results through the NeXT electronic mail (e-mail) system.

In this lab we will explore further *Mathematica*'s ability to do derivatives and we will see how it can graph functions. As in all our labs, we will use a prepared *Mathematica* notebook to facilitate the execution of *Mathematica* commands.

This lab also introduces the use of the NeXT's *WriteNow* word processor for writing your lab reports.

Step 1

Log in to one of the NeXT workstations, just as you did in the Introductory Lab.

The *Mathematica* notebooks for this course are in the **/Net/newton/Users/math212/notebooks** directory. To access it, you need to use the **File Viewer** window of the **Workspace Manager**.

The **Workspace Manager** icon The **NeXTstation** icon

Figure 1 Some of the NeXT icons

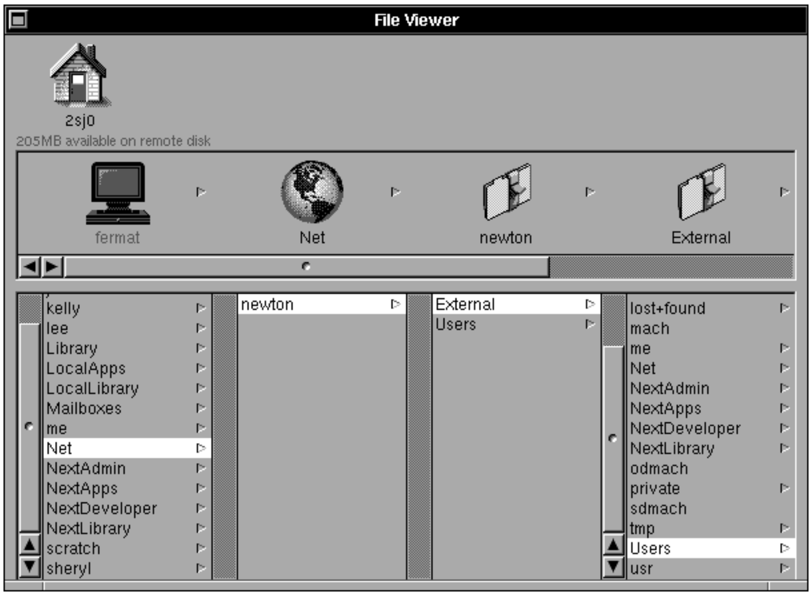


Figure 2 The File Viewer with root directory visible

If it is not now your active window, double-click on the **Workspace Manager** icon.[1] Then slide the horizontal slide bar on the File Viewer to the left as far as it will go. This will reveal the root directory of your NeXTstation (Fig. 2). The NeXTstation icon appears at the top of the left-most column. That column lists all the files in your NeXTstation's root directory.[2]

The second row of your File Viewer contains the NeXTstation icon, a globe icon, and two file folder icons. Each icon on this row represents a directory which is a subdirectory of the directory to its left. In Fig. 2 you can see that the **External** directory is a subdirectory of the **newton** directory, which is a subdirectory of the **Net** directory, which is a subdirectory of your workstation's root directory.[3]

The contents of each directory are listed in the column below the directory's icon. For example, the contents of the **External** directory are listed in the right-most column in Fig. 2. Notice that most of these files have a little triangle to the right of their names. The triangle indicates that the file is actually a subdirectory containing more files. The triangle points to the next column on the right which shown the contents of the directory selected.

Click on the **Users** listing in the **Net** column to select the **Users** subdirectory:

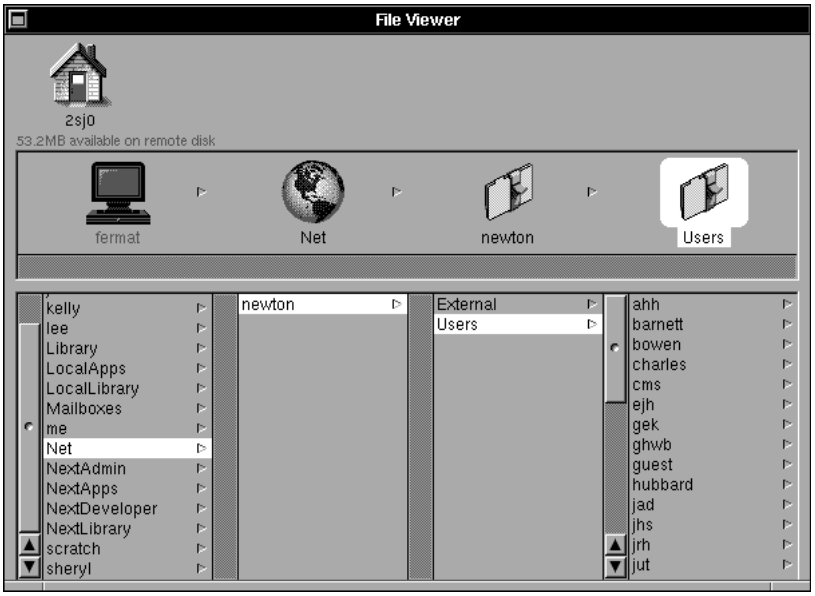


Figure 3 The /**Net**/**newton**/**Users** path

The /**Net**/**newton**/**Users** directory contains the account files of faculty and student assistants.[4] To see them all, slide the vertical slider on **Users** column downward. As you move the slider, the list of these user accounts scrolls upward.

[1] The NeXT cube in the upper right corner of your screen.
[2] Among them are the **LocalApps**, the **NextApps**, and the **NextDeveloper** directories. These three directories contain many applications that you may find interesting.
[3] The name of your workstation appears underneath the NeXTstation icon. Each NeXTstation is named after a great mathematician who contributed to the development of the calculus: newton, fermat, cauchy, wallis, barrow, kepler, etc.
[4] All the regular student accounts are in the /**Net**/**newton**/**External**/**Users** directory.

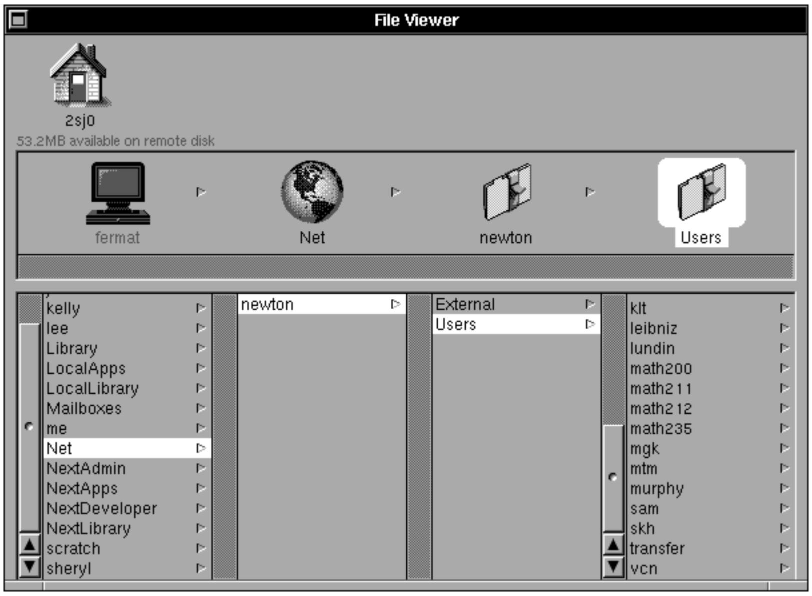


Figure 4 After scrolling through the /**Net**/**newton**/**Users** directory

To see the contents of the /**Net**/**newton**/**Users**/**math212** directory, click on the **math212** listing in the **Users** column. This will shift the Browser's columns to the left to reveal the **math212** directory file:

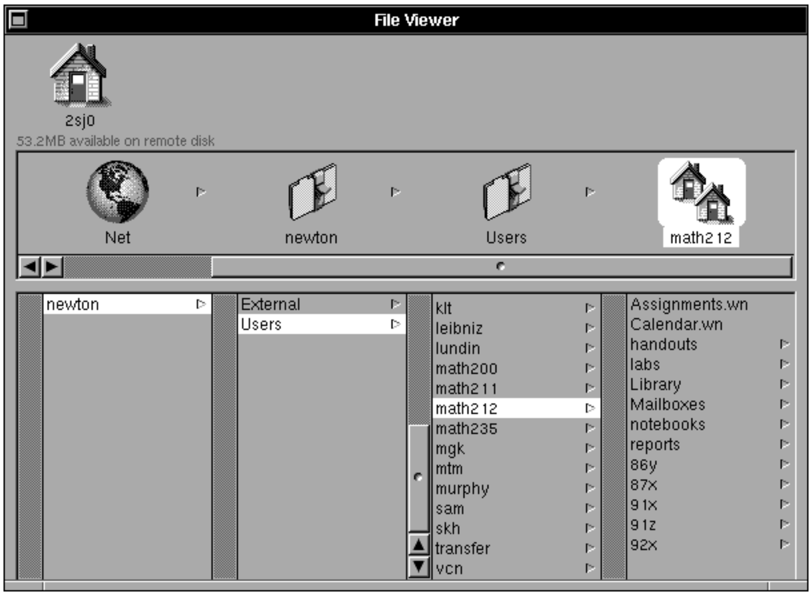


Figure 5 Showing the contents of thee **math212** directory

Notice that the icon for the **math212** directory file is a pair of little houses. This represents the notion that you are now accessing two different user accounts: yours and the **math212** account.

During the semester you will be accessing the **math212** account frequently. To facilitate this access, drag the two-house icon up onto the "shelf" of the Browser (the top row), next to your own house icon.

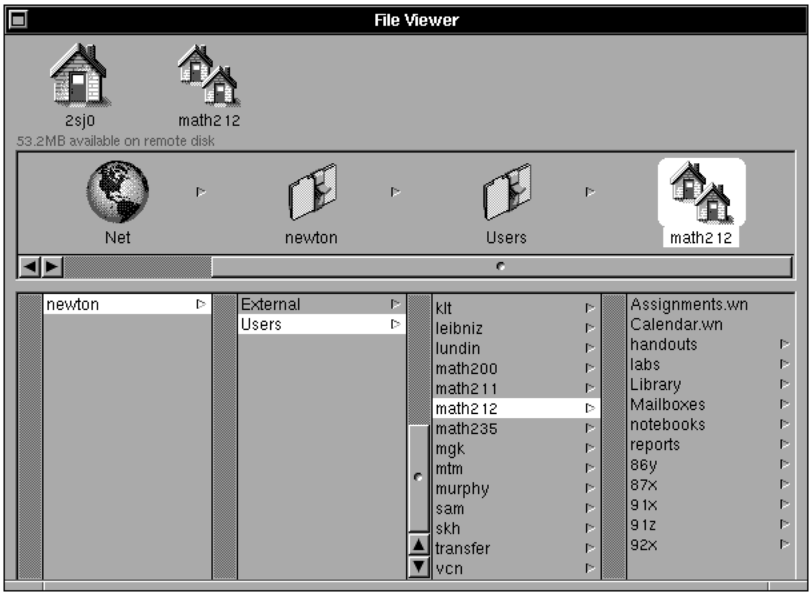


Figure 6 After dragging the **math212** icon on the Browser's shelf

The **math212** icon will remain on your shelf unless you remove it. So now you can immediately access the **math212** account directory any time just by clicking on its icon there on the shelf.[5]

Now to get to the *Mathematica* notebook for this lab, click on the **notebooks** listing in the **math212** column, and then click on the **Lab1.ma** listing in the **notebooks** column:

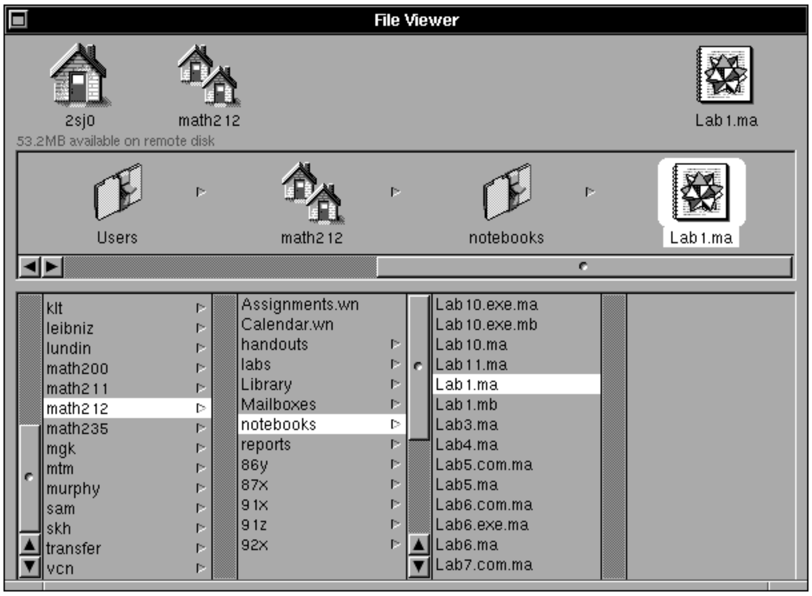


Figure 7 Selecting the **Lab1.ma** file in the **math212/notebooks** directory

Notice that the icon for a *Mathematica* notebook is a little spiral notebook with a picture of the *Mathematica* icon on its cover. Use the mouse to drag the notebook icon up on to the shelf.

[5] The File Viewer's shelf is used to store icons of frequently-used files. Whenever you click on one of these, the File Viewer's Browser immediately shifts to reveal the file's location within the NeXT network's subdirectory forest.

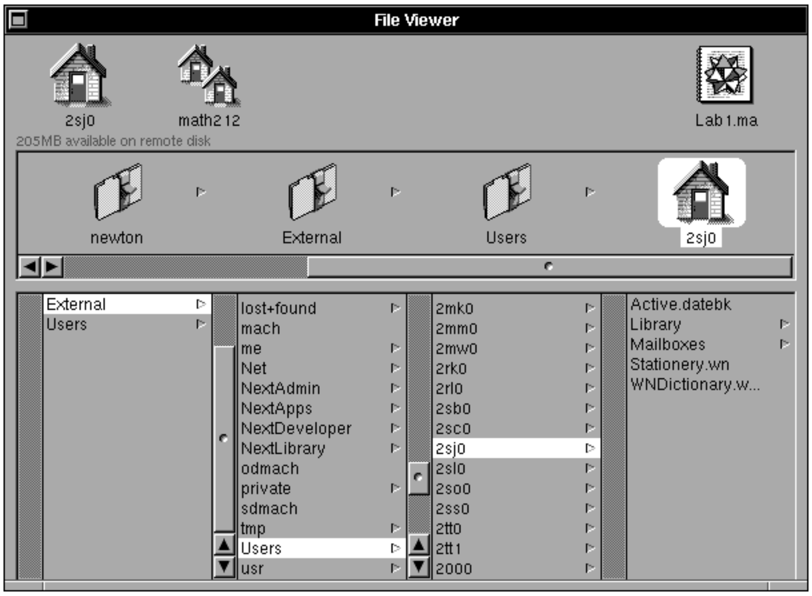


Figure 8 After dragging a copy of the **Lab1.ma** file icon onto the shelf

Now click on your own home directory icon (your house) to select your home directory, and then drag the notebook file icon down from the shelf onto your house icon. When the notebook icon reaches the house icon, the house's little door opens to welcome in the notebook. Then when you release the mouse button, the door closes and the **Lab1.ma** file name appears in the column under the house:

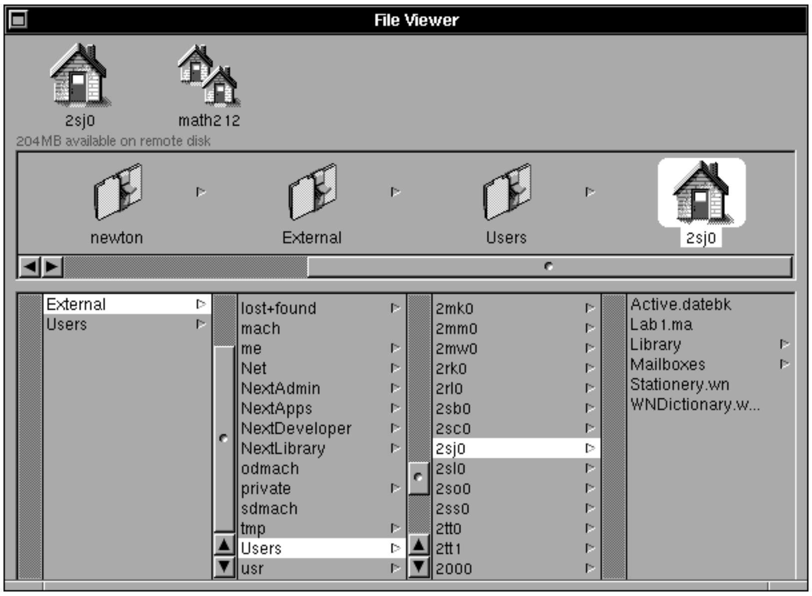


Figure 9 After copying the **math212/Lab1.ma** file into your own account

You will be copying files frequently this semester from the **math212** account into your own account. Each time, simply click on the **math212** icon, drag the file icon onto the shelf, click your own account icon, and drag the file icon down into your house as you did here. That's all there is to it.[6]

[6] You could copy the document you are reading now. As is indicated on the bottom of the last page, it is in **math212/labs/Lab1.wn**

Step 2

Now double-click on the **Lab1.ma** listing in your account directory. This will activate *Mathematica* and open the notebook:

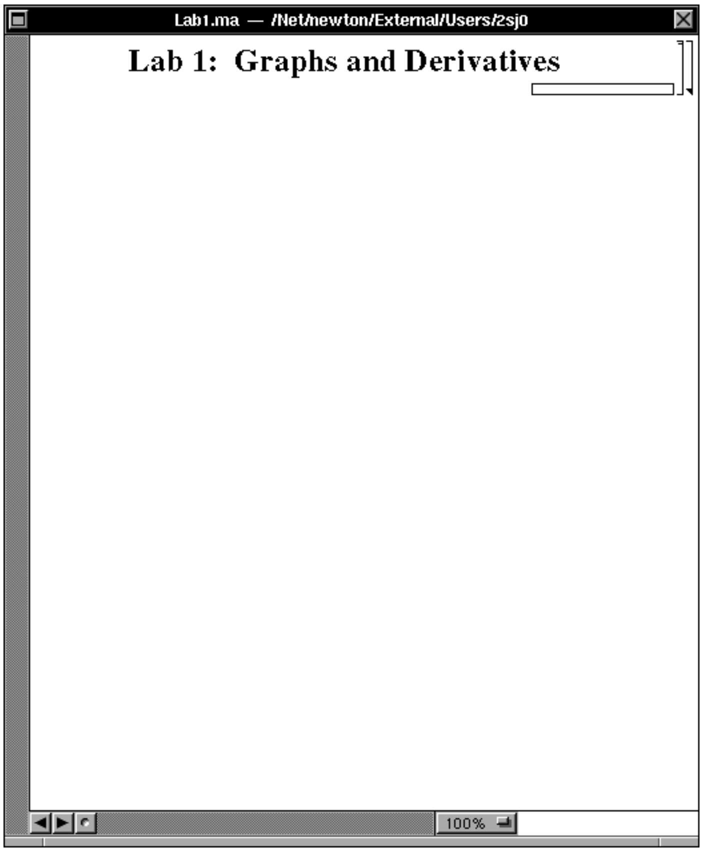
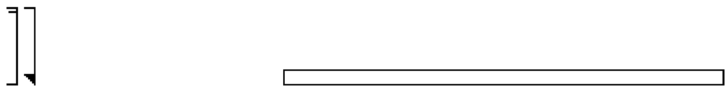


Figure 10 The **Lab1.ma** notebook

Notice that the file name and its path are shown on its title bar:

Figure 11 The window's title bar

The file name is **Lab1.ma**, and **/Net/newton/External/Users/2sj0** is it path name.[7]
The *Mathematica* notebook shows only its title **Lab 1: Graphs and Derivatives** and some markings to the right. The two bracket-like symbols are called *cell indicators*.



cell indicators a group box

Figure 12 Symbols used in *Mathematica* notebooks

[7] except that your user name will appear in place of **2sj0** (Steve Jobs' user name).

The long narrow rectangle on their left is called a *group box*. It indicates that a subgroup of cells is hidden here. To reveal the hidden group, double-click on the group box:

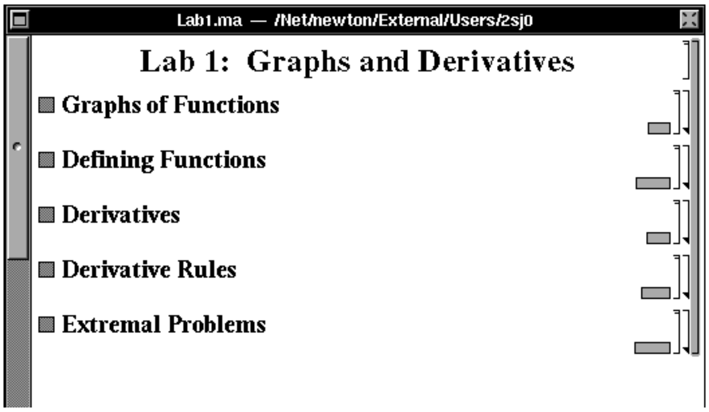


Figure 13 After opening the main cell

Now you can see the five sections that comprise the **Lab 1** notebook. Notice that each of these sections has its own cell indicators and group box. The size of the group box indicates the size of the hidden group. For example, the group hidden in the **Derivatives** section is about 60% the size of the group hidden in the **Defining Functions** section.

Double-click on the group box for the **Graphs of Functions** section. This opens three smaller cells: a paragraph of text, a subsection named **Example**, and a subsection named **Exercises**:

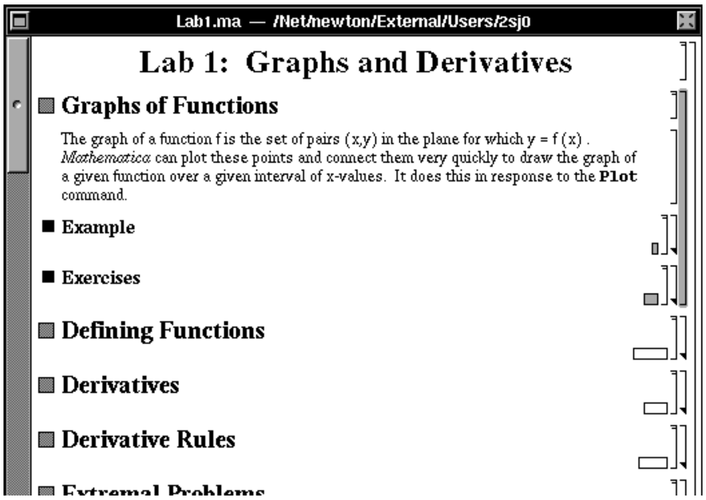


Figure 14 After opening the **Graphs of Functions** section

After reading the introductory paragraph, double-click on the **Examples** box to open it. Read through this section.

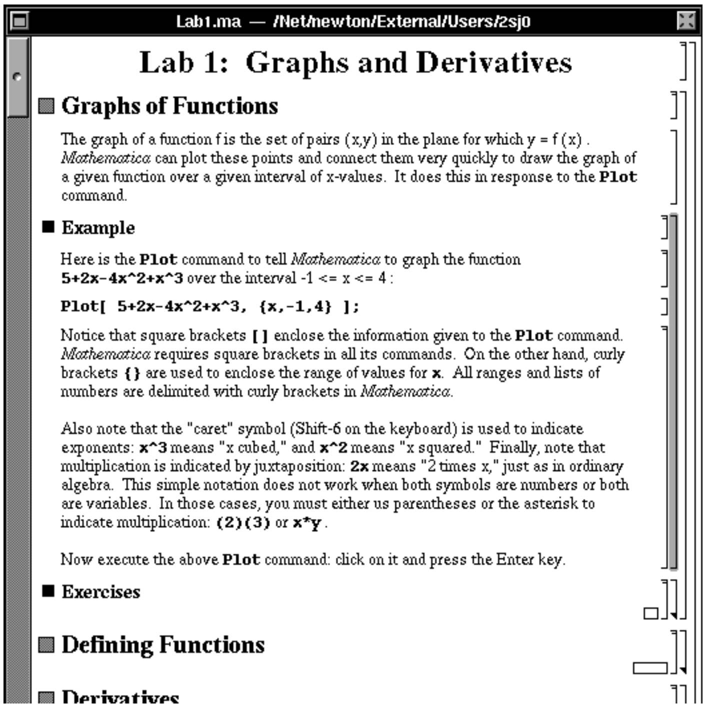


Figure 15 After opening the **Example** subsection

When you come to the **Plot** command, execute it: click on it and press the Enter key. After a few seconds, it should produce the graph shown in Fig. 16.[8]

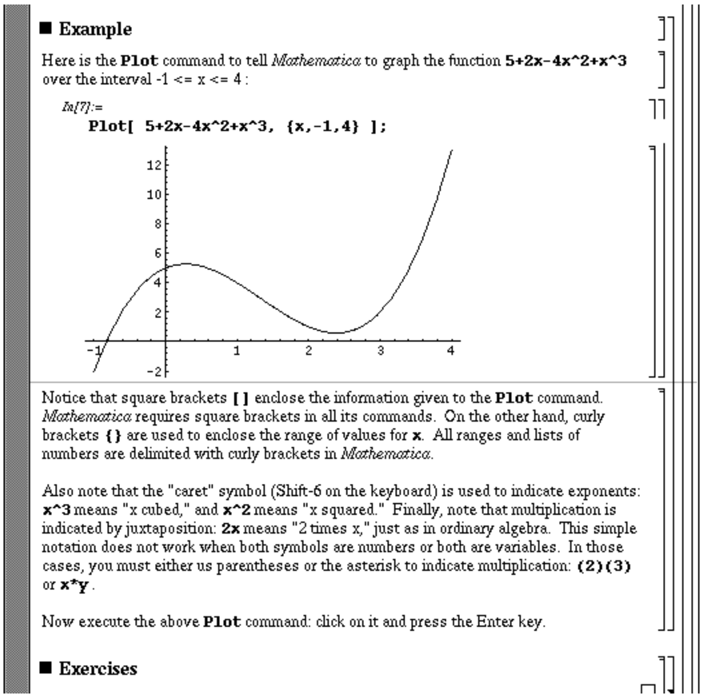


Figure 16 After executing the command in the **Example** subsection

[8] The first command you execute in a new *Mathematica* window will take 20 to 30 seconds because *Mathematica* does a lot of initializations. The title bar on the window will show the message **Running…** while *Mathematica* is running. You won't be able to do anything else until it has finished.

Step 3

Now open the **Exercises** cell and work through the exercises.

Each of these exercises require you to execute a **Plot** command. To save time and typing errors, use the **Copy** and **Paste** commands to copy the **Plot** command from the Example subsection down into each exercise.[9] After you paste the command in, you can edit the parts of it to match the exercise.[10]

After you finish all the exercises in the **Graphs of Functions** section, close the section by double-clicking on its cell bracket.

Step 4

Work through the remaining four sections of **Lab1** in the same way. Work all the exercises, inserting your own input cells. Be sure to execute all the *Mathematica* commands in each section. Also be sure to open all hidden cells.

<u>Remember to **Save** your window every few minutes.</u>[11]

Most of the sections in our notebooks will have the same general structure: an introductory text cell followed by an **Examples** subsection and an **Exercises** subsection. In each case, you should read the introductory text (if any), then open the **Examples** subsection and read through it, executing all the *Mathematica* commands in it, and then open the **Exercises** subsection and work through it.

After you finish working through the entire notebook and have completed all the exercises, close all the cells, and save [12] your modified file.

Step 5

After you and your lab partner together have worked through the notebook, you are each ready to write your individual lab reports. Each of you needs to work at a separate NeXTstation to do this.

Launch the *WriteNow* word processor by double-clicking on its icon.

Figure 17 The *WriteNow* icon

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[9] Drag across the **Plot** command; press **Command-c** to copy the line onto the Pasteboard buffer; click between two Exercise cell brackets to establish an insertion point; press **Command-v** to paste the line at that insertion point.
[10] For example, in Exercise 1, to insert **x^2-4** in place of the other function, drag across the other function to select it, and then just type **x^2-4**
[11] Use **Command-s**
[12] As a shortcut, instead of using the **Windows** menu, you can click on the **Save button** in the upper right corner of the window. A **Save** panel will pop up, to which you can simply press the Return key to complete the save.

This will bring up a template file that looks like Fig. 18.[13]

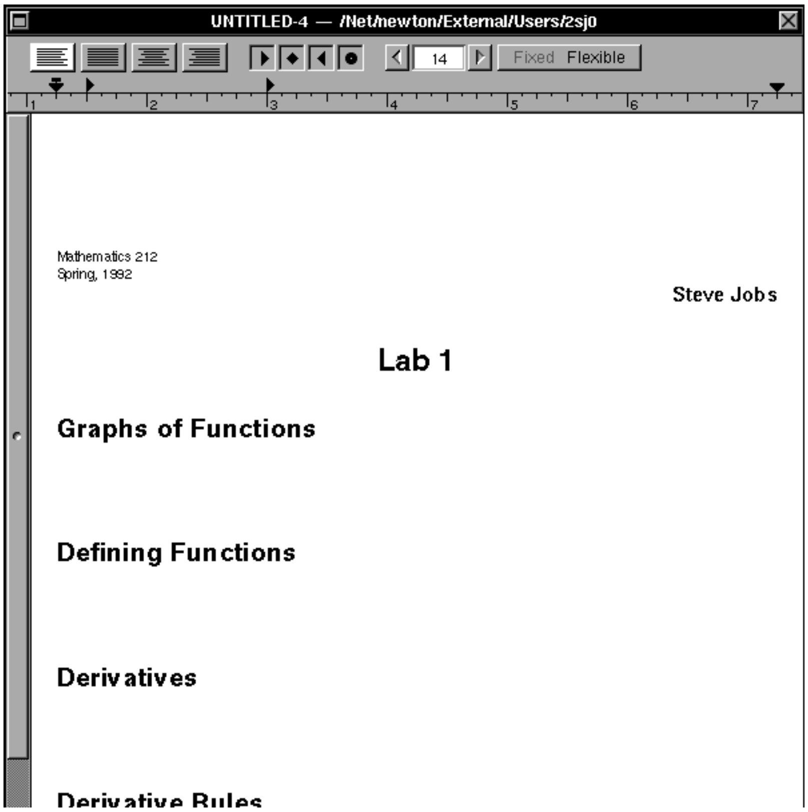

Figure 18 Steve Jobs' *WriteNow* template file

All you need to do is fill in the blanks…

The purpose of the lab report is for you to describe what you have learned from working through the *Mathematica* notebook. Most of your references should be to the exercises that you worked. Be sure to include any extra experimentation that you might have done to investigate *Mathematica*'s ability to do calculus beyond that described in the notebook. Write at a level that your roommate could understand.

Use the **Copy** and **Paste** commands to copy commands, output, and graphs from your notebook to your lab report.

Don't forget to **Save** your file every few minutes.

Here are some ideas that you might want to consider in your report:[14]

Graphs of Functions

1. What does the **Plot** command do?
2. What information does the command need?
3. How do *Mathematica*'s plots differ from what a human might draw?

[13] except that it will have your name instead of Steve Jobs
[14] You do not have to use these ideas, and you may certainly use others.

4. Does *Mathematica* make it easier to graph functions?

Defining Functions

1. Why is it good to define a function before operating on it?
2. How are the graphs of `f[x]` and `f[-x]` related?
3. How are the graphs of `f[x]` and `-f[x]` related?
4. How are the graphs of `f[x]` and `-f[-x]` related?
5. What if the graphs of `f[x]` and `f[-x]` are the same?
6. What if the graphs of `f[x]` and `-f[x]` are the same?
7. What if the graphs of `f[x]` and `-f[-x]` are the same?

Derivatives

1. Does *Mathematica* make it easier to find derivatives?

Derivative Rules

1. Why did you have to `Clear[f]`?
2. What sort of generalizations can you draw from the exercises?

Extremal Problems

1. What's the difference between an algebraic answer and a numeric answer?
2. Does *Mathematica* make it easier to find maxima and minima?

Step 6

Mail your lab report to the **math212** account. To do that, do these things:

1. Double-click on the Mail application to activate it.
2. Click on the Send button
3. Type **math212** in the "To:" field.
4. Type **Lab 1** in the "Subject:" field.
5. Click in the large white section of the Send window to establish an insertion point there.
6. Drag the Send window off to the side of your screen so that it will be partially visible underneath the File Viewer.
7. Activate the File Viewer.
8. Select your **Lab1.wn** file.[15]
9. Drag that file's icon over to the large white space in your Send window.
10. Activate your Send window again.[16]
11. If you don't see the file's icon in the large white space, repeat steps 5-10.
12. Press the Deliver button.

[15] Your lab report—<u>not</u> your *Mathematica* notebook.
[16] A window is activated either by clicking on it or by double-clicking its application icon on the dock.

Mathematica Commands

Here are some of the *Mathematica* commands that you might use in this lab:

`Plot[ 5+2x-4x^2+x^3, {x,-1,4} ]`	Draws the graph of `y = 5+2x-4x^2+x^3` for `x` in the range `-1` to `4`.
`f[x_] := 5 + 2x - 4x^2 + x^3`	Defines the function `f`.
`Plot[ f[x], {x,-1,4} ]`	Draws the graph of `y = f[x]` for `x` in the range `-1` to `4`.
`D[ x^3-4x^2+2x+5, x ]`	Produces the derivative (with respect to `x`) of the expression `x^3-4x^2+2x+5`.
`f[x]`	Produces the current expression for `f[x]`.
`f'[x]`	Produces the derivative of `f[x]`.
`f'''[x]`	Produces the third derivative of `f[x]`.
`Solve[f'[x]==0,x]`	Solves the equation `f[x]=0` for `x`.
`N[%]`	Produces a numerical (decimal) approximation to the last output.
`f[x] /. %`	Evaluates `f[x]` for `x` equal to the last number output.
`f''[x] /. %%`	Evaluates `f''[x]` for `x` equal to the second-from-last number output.