# Lab 4: Derivatives

This lab shows how we can use *Mathematica* to computes partial derivatives and to solve extremal problems.

## Step 1

Copy the **/math235/notebooks/Lab4** notebook into your own **notebooks** directory, as you did in Step 1 of Lab 3. Then work through the notebook. Be sure to open all subcells and to work all the exercises. You may wish to refer to the Appendix at the end of this Lab; it lists most of the *Mathematica* commands that you might need in the notebook.

## Step 2

Launch the WriteNow text processor as you did in Lab 3. Insert your name and your lab partner's name at the top, change the heading to read **Lab 4: Derivatives**, and change the section headings to **Partial Derivatives**, **The Gradient Function**, **Critical Points**, **Higher Derivatives**, and **The Second Derivative Test**. Then save the file as **Lab4** in your **reports** directory. It should look like Fig. 4.1.

## Step 3

As you did in Lab 3, write a brief description of what you learned in each section.

In addition to copying *Mathematica* commands from the notebook to your lab report, you can also copy graphics. For example, in the third section (Critical Points), the contour plots helped you visualize the behavior of saddle points and extrema. It would help your explanation of this behavior to include these plots in your report.

To copy a graphical image from a *Mathematica* notebook[1] to your lab report, double-click on the graph itself (Fig. 4.2). This *selects* the graph. A gray frame appears enclosing the graph to show its size and that it is selected.

Now select the Copy command from the Edit submenu[2] to copy the graphic image onto the pasteboard. Then activate your *WriteNow* window and then click at the point in your lab report where you want to insert the graph.[3] Then select the Paste command from the Edit submenu[4] to paste the graph into your lab report. (Fig. 4.3)

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[1] Actually, this same procedure can be used to copy a graphical image from any system on the NeXT to any other system (Mathematica to Mail, Webster to WriteNow, etc.)
[2] Or just press Command-c.
[3] You will probably have to click twice: once to activate your WriteNow window, and once to set the insertion point in the document itself.
[4] Or just press Command-v.

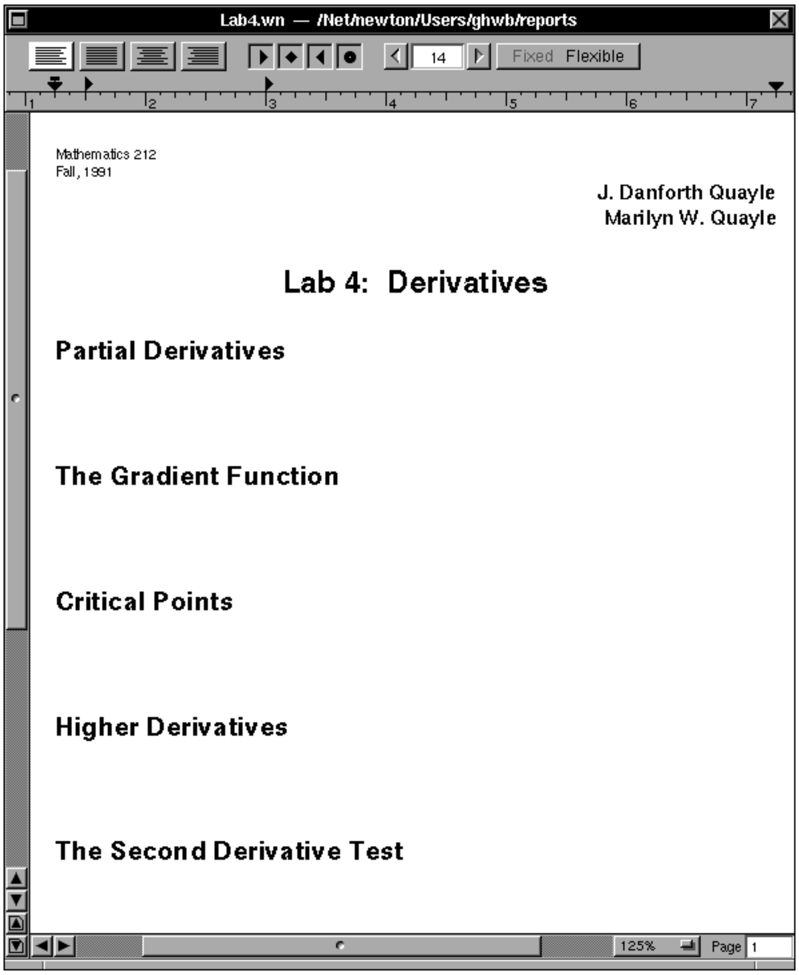


Figure 4.1 Outline of lab report for Lab 4

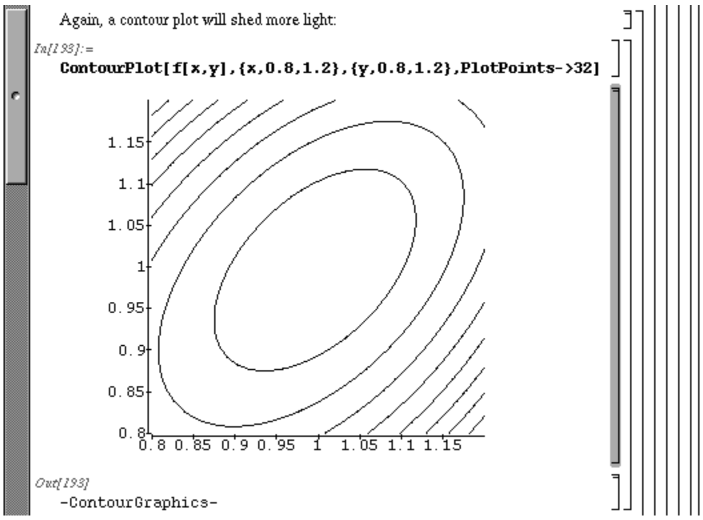


Figure 4.2 Selecting a graph in a *Mathematica* notebook

## Step 4

After pasting the graph in your lab report, you may want to change its size.[5] Resizing an image is very easy on the NeXT. Just double-click on the graph to select it. Once selected, a gray rectangle frames it. Then drag, either towards the middle to contract the graph, or away from the middle to expand it. As you drag, the horizontal and vertical dimensions are displayed at the lower right corner of the window. For example, the image in Fig. 4.4 shows the reduction to 66.0% in the horizontal dimension and 65.5% in the vertical dimension.

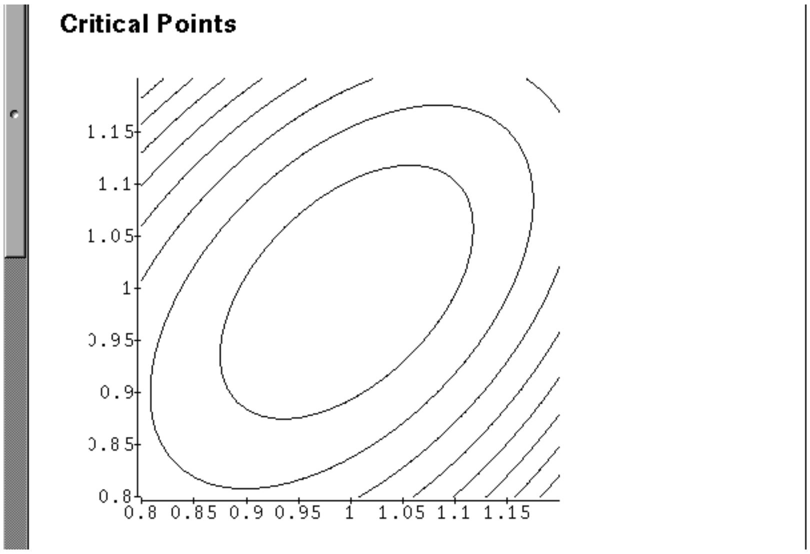


Figure 4.3 After pasting the graph into the WriteNow file

Notice that, as soon as you move the I-beam inside the gray rectangle, the I-beam changes to an arrow. This is to tell you that you can now drag to resize.

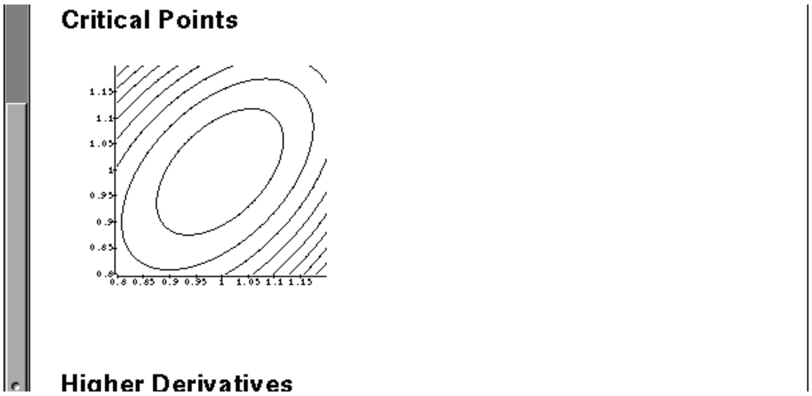


Figure 4.4 After contracting the image

[5] You can also change the size of a graphics image in Mathematica— before you copy and paste it. The resizing process works the same way on all systems on the NeXT.

If you want to restore the image to its original size, hold the Shift key down and click within the gray rectangle.

## Step 5

As you did in your Lab 3 report, you will probably want to copy some input and output from your *Mathematica* notebook to your report for this lab. For example, the definition of the discriminant given in the last section should be explained in your report.

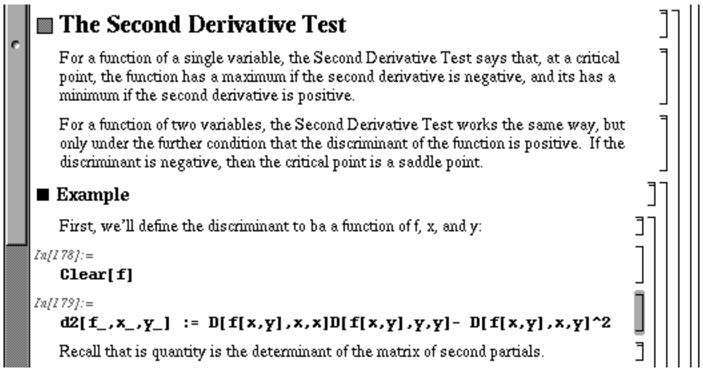


Figure 4.5 *Mathematica* definition of discriminant selected


Figure 4.6

Here's how to copy the cell that defines the discriminant. Click on the cell indicator bracket at the right edge of the window. When selected, the bracket will be shaded gray (Fig. 4.5).

Now to copy this cell, you could click on the Copy command in the Edit submenu, as you have done before. However, if you look closely at that command (Fig. 4.6), you'll see the small letter c on the Copy command at its right. This tells you the "short cut" for the Copy command: instead of clicking on that menu command, hold the Command key [6] down and press the C key.

Now activate your WriteNow window and click in the last section to set the insertion point there. Then hold the Command key down and press the V key. Notice the small letter v to the right of the Paste command on the Edit submenu (Fig. 4.6). This pastes into your lab report the lines that you just copied. Remember these two letters ( c for Copy, and v for Paste ) to work more efficiently.

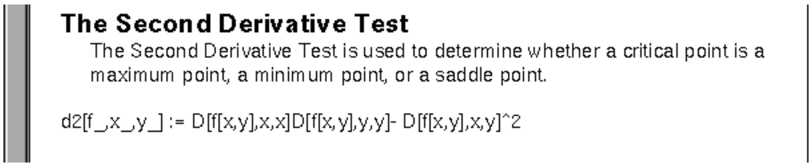


Figure 4.7 After pasting the lines into the WriteNow file

[6] There are two Command keys on the keyboard, one at each end of the space bar. Each is labeled in green.

## Step 6

The text you have just copied would be easier to read if it looked more like it does in the *Mathematica* file.  To make it so, you will need to use the Font Panel.

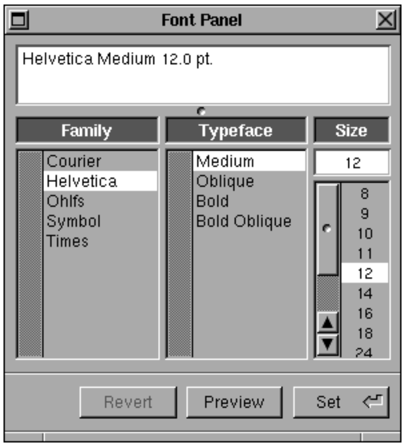


Figure 4.8  The Font Panel


Figure 4.9

To bring up the Font Panel, click on the Font command in the WriteNow menu and then click on the Font Panel… command in the Font submenu.[7]  This panel, which is available in every NeXT system, allows you to change the fonts on your text.  It shows the current type font in two ways:  it lists it in its text window, and it shows it by highlighting the font's three components in its Family, Typeface, and Size columns.

There are five font families:  Courier, Helvetica, Ohlfs, Symbol, and Times.  The default font is Helvetica.  Normally, each font has four typefaces: Medium, Oblique (also called "Italic"), Bold, and Bold Oblique.  The default typeface is Medium.  The font size can be just about anything.  It is measured in points.  (A *point* is 1/72nd of an inch.)  The default font size is 12-point (1/6th of an inch).

The current font (highlighted in the Font Panel) is 12-point Helvetica Medium.  This is the default in *WriteNow*.  The default font in *Mathematica* is 12-point Courier, Bold for input and Regular for output.

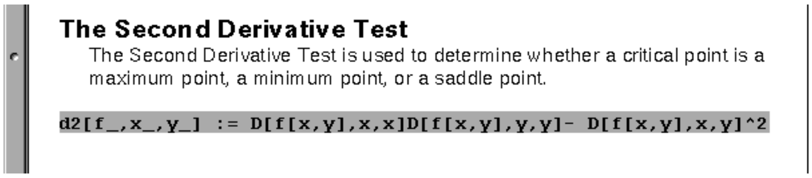


Figure 4.10  After selecting the new lines

[7] Notice that you could have just pressed Command-t to bring up the  Font Panel.

Select[8] the *Mathematica* lines you just pasted into your lab report.
In the Font Panel, click on Courier and on Bold, and then click on the Set button. This changes the font of the selected six lines from Helvetica to Courier-Bold.

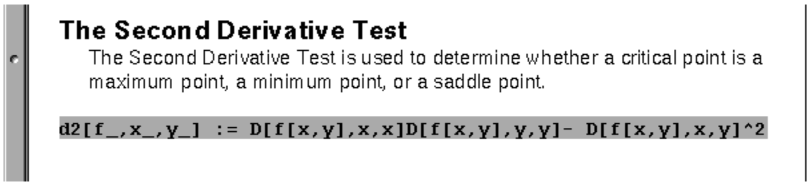


Figure 4.11 After change the font to Courier Bold

## Step 7

You might want to experiment with the various fonts. Courier is the only equally-spaced font; it is used mostly in computer programs (like *Mathematica ).* Helvetica is the font of choice for ordinary writing. Ohlfs is a specialized font used only in screen displays. Symbol provides Greek letters and mathematical symbols. Times is a classical font.

Besides the Symbol font, you can also create symbols using the Alternate key. For example, the symbols $\leq$ and $\geq$ are produced by Alternate-Shift- < and Alternate-Shift- > .

## Step 8

After you finish writing your Lab report, mail it to **math235**, just as you did in Lab 3.

[8] Remember that a block of text is selected by clicking the insertion point at one end and then dragging to the other end. An alternative method (good for large blocks of text) is to click at one end, and then hold the Shift key down while clicking at the other end (called “Shift-click”).

## Appendix: *Mathematica* Commands

Here are some of the *Mathematica* commands that you will need for this lab:

| | |
|---|---|
| `f[x_,y_] := x^2 y^3` | Defines the function **f** . |
| `f[x,y]` | Requests the current definition of the function **f** . |
| `D[f[x,y],x]` | Produces the partial derivative of **f** with respect to **x** . |
| `Clear[f]` | Removes the current definition of the symbol **f** . |
| `Simplify[%]` | Simplifies the previous answer. |
| `grad[f_,x_,y_] := {D[f[x,y],x],D[f[x,y],y]}` | |
| | Defines the gradient of **f** at (**x**,**y**). |
| `grad[f,x,y]` | Requests the current definition of the function **grad** . |
| `Solve[grad[f,x,y]==0,{x,y}]` | |
| | Solves the equation **grad[f,x,y] = f[x]** for (**x**,**y**). |
| `/. {x -> 0, y -> 0}` | Replaces **x** with 0 and **y** with 0 in the current answer. |
| `Plot3D[f[x,y],{x,-0.2,0.2},{y,-0.2,0.2},PlotPoints->32]` | |
| | Plots the graph of the function **f** over the region where $-0.2 \le$ **x** $\le 0.2$ and $-0.2 \le$ **y** $\le 0.2$, using 32 points in each dimension. |
| `ContourPlot[f[x,y],{x,-0.2,0.2},{y,-0.2,0.2},PlotPoints->32]` | |
| | Plots the level curves of the function **f** over the region where $-0.2 \le$ **x** $\le 0.2$ and $-0.2 \le$ **y** $\le 0.2$, using 32 points in each dimension. |