

Directions: Work in the same groups you did in lab 1. Turn in only one lab but include all names.

Have your first lab handy for reference. This lab assumes knowledge of the first. The work that you turn in related to this lab is due at 9:00 am on Monday of the 3rd week of the block. You will turn in your work electronically. I will give instructions in class on Thursday.

In this lab we intend to have you:

- Learn to utilize some additional features of Mathematica;
- Enhance the appearance of the outputs from Mathematica;
- Incorporate Mathematica into your written work.

You need to be familiar with Microsoft Word. If not, you will need some additional assistance. The general idea is to let Mathematica do the hard work for you and then copy and paste your solutions including graphs into a word processing document.

Not surprisingly (☺), Mathematica does calculate derivatives. There are several ways to do this.

A. Define the function $f[x_] := x^4 - 3x^2 + 2x - 1$ (see lab 1, if you have forgotten how). The previous statement assigns the expression $x^4 - 3x^2 + 2x - 1$ to the function $f[x]$.

Now, you can obtain the derivatives by using the standard apostrophe, i.e. $f'[x]$ and $f''[x]$ refer to the first and second derivatives, respectively. (Try typing $f'[x]$ and executing with Shift-Enter.) In class we have begun discussing the relationships among these functions. When f' is negative, you see f has negative slope, when f' is positive, you see f has positive slope, etc. Graphing these on the same axes allows for easy comparison. To do so, just remember that groups or sets of objects are placed in curly brackets. Thus, you need to execute:

```
Plot[{f[x], f'[x], f''[x]}, {x, -3, 3}]
```

You can label the graphs with text. Right click on the graph and select drawing tools. Click the icon on the very bottom left to obtain Traditional Form text. Then click on the graph where you want to enter the text and begin typing. Try labeling the graphs with $f[x]$ and $f'[x]$, etc.

Exercise 1: Plot $f''(x)$, $f'(x)$ and $f(x)$ on the same axes. Label each using with Traditional Form text. Copy and paste your graph into your word document.

You can find where $f(x)$ has 0 slope by setting $f'(x)$ equal to zero and having Mathematica solve the equation. To distinguish from = as an assignment, use two equal signs, ==: execute `Solve[f'[x]==0,x]`

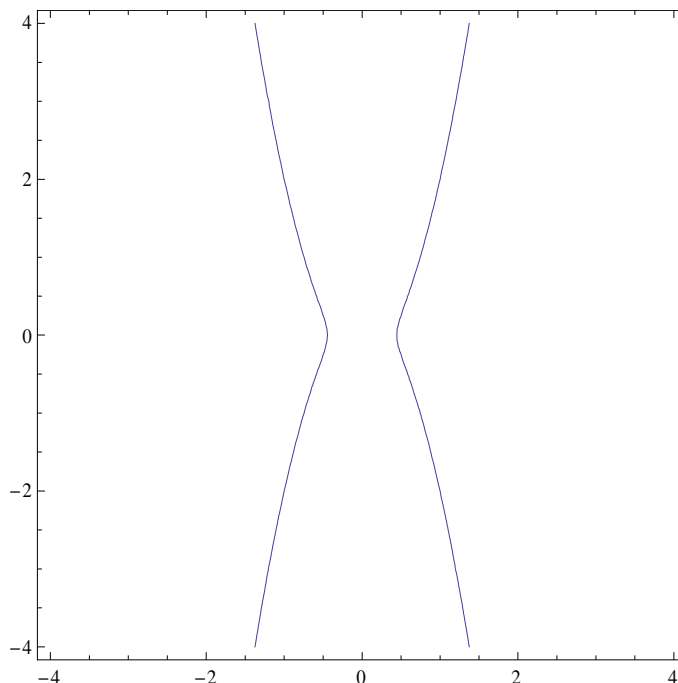
Mathematica will solve an equation algebraically if possible. You can always approximate these solutions with decimals by using `NSolve[]` initially or with the `N[]` function after the fact.

Mathematica will find the equations of tangent lines to curves at points you specify and plot these. The process is easy because of your new knowledge of math and calculus. For example, let's consider our function $f[x]$ at $x = -2$. Try: `Plot[{f[x], f'[-2](x-(-2))+f[-2]}, {x, -4, 4}]`. Notice how we slightly modified the point-slope form. This is called the Taylor form.

B. Two other forms for the derivative are very handy. `D[f[x], x]` gives $f'(x)$, the derivative of f wrt x . Mathematica also is happy to differentiate and plot non-functional (implicit) expressions. The form for the derivative `Dt[f[x,y]==g[x,y], x]` is handy for this (by the way `Dt` stands for 'total derivative'). Suppose we want to plot. Consider the relation $y^2 = 5x^4 - x^2$. Execute `Dt[y^2==5x^4-x^2, x]` (notice the 'double equal sign' rather than the single equal sign). The result includes the expression `Dt[y, x]`. This of course represents $\frac{dy}{dx}$. Mathematica conveniently allows you to solve for this quantity;

Try: `Solve[Dt[y^2==5x^4-x^2, x], Dt[y, x]]`. The result is `Dt[y, x] → $\frac{-x+10x^3}{y}$`

To plot implicitly, use: `ContourPlot[y^2==5x^4-x^2,{x,-4,4},{y,-4,4}]`. The result is



You now know what the curve looks like. Does the symmetry surprise you?

C. As you may have noticed, I have embedded and resized Mathematica expressions and Mathematica plots in this Word document. You can do so as well and, thus, construct visually pleasing mathematical documents.

To copy a Mathematica plot window, simply right click and Copy Graphic. Paste your graph into the Word document. You may resize it and move it around in the usual way. If you are unfamiliar with Word, then ask for help or use a word processor with which you are familiar.

Copying an algebraic expression from Mathematica algebra requires a bit of effort. Highlight an algebraic expression and right click. Select Copy As and MathML. Paste into your work document. This is now an equation in Word.

D. You can save your Mathematica worksheet on your h:-drive. Click **File|Save As** and then follow the usual regimen.

Exercise 2: Use Mathematica and a word processor to construct a practice exam and solutions to help you prepare for the final. Embed appropriate expressions and graphs from Mathematica into your document. Your practice exam is to consist of 4 problems. You should place the solutions on a separate page(s) of the document. One problem should deal with an inverse trig function; another should be calculation of a derivative directly from the limit definition; and the final two should require the application of the derivative rules of various types. I include an example; notice how I mix in output from Mathematica:

Problem: Let $f(x) := x^2 \cdot \text{SIN}(x)$; calculate $\frac{d}{dx} f(x)$.

Solution: $x^2 \cdot \text{COS}(x) + 2 \cdot x \cdot \text{SIN}(x)$ (by the product rule)

Note: In the course of doing this lab, also be sure the printer in Tutt Science 213 is installed on your user number for future use. Turn in this lab electronically (to be discussed on Monday).