# Math 251: Computational Lab 0

## Fall 2019, Sections 1-3

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| Instructor: | Matt Charnley |
| Recitation Instructor: | Some TA |
| Due Date: | September 1, 2019 |

## Introduction

You are encouraged to discuss this assignment with other students and with the instructor/recitation instructor, but the work you hand in should be your own. See the website

`http://math.rutgers.edu`

for more information as well as helpful background information and commands for completing the assignment.

In addition, the reference pages for each of the computer systems will have more detailed information about how to do each of the tasks presented here. You should have that webpage open while working through this lab, as well as future labs if you need guidance. It is advised for you to work through all of the examples there before you try to move on to the ones you are asked for on this worksheet. The point of this lab is for you to play around with the computer algebra system, see how it works, and get familiar with it so that the remaining labs (that have actual course material in them) are easier to handle.

Finally, all of the computer systems have extensive and very well-written *help* documentation, that can either be accessed from inside the program (just type help and that'll get you started) or just Googling things. If you can't find it that way, ask your instructor and they can help you get what you need.

## 1 Basic Structure

The goal of the first section is to figure out how the computer algebra system works and how to put your name on documents. You should do the following:

1. Open your desired computer algebra system and a document that you can write code in.
2. Make a commented header including the title of this assignment, your name, and today's date.
3. Save the file (as a document you could reopen in this program) and then save a published version of it as a PDF that you could print and give to your instructor. Don't actually print though, this is just practice.

## 2 Arithmetic

The point of using a computer is that it can do calculations for us. Play around with doing a variety of calculations in your computer system, both with suppressing and not suppressing output. In particular, get the computer to do the following:

1. $2^{300} \cdot 300^2$
2. $4/7$ and then on the following line, multiply this by 700.
3. $(\sqrt{2} - 1)^5$, both algebraically and numerically.
4. $e^{\pi\sqrt{163}}$ to 30 decimal digits of accuracy.

## 3 Algebra

The particular benefit of the computer algebra systems that you can choose from for this class is that they can handle both numerical and symbolic computation. In this section, you'll start seeing how algebra problems can be solved using these systems. Play around with defining and factoring polynomials, setting up functions, and evaluating them at a variety of points. At the end, do the following:

1. Factor $p(x) = x^4 - 3x^2 + 1$. What do you get in terms of real and imaginary roots? In particular, figure out how you could access these roots later on.
2. Take the expression $x^3y + xy^2$ and do the following
   (a) Substitute $x = 1$.
   (b) Substitute $x = 1$ and $y = x$ (this should result in a polynomial in $x$)
   (c) Evaluate this at $x = 2$, $y = 3$.
3. Define the function $f(x) = \left(x + \frac{1}{x}\right)^3$ in at least two different ways. Using these different definitions, find the value of $f(\sqrt[3]{2})$ both algebraically and numerically. This may be harder (or even impossible) with some definitions of the function. Getting a handle on this is the point.
4. Find the coefficient of $r^7$ in $(r^2 + 3r + 4)^{10}$.

## 4 Calculus

In addition, these systems can do calculus on symbolic functions. They can also do integration numerically if it can not be done analytically. Play around with different functions and doing calculus with them. Afterwards, do the following:

1. Calculate the second derivative of $x^3 \ln x$ and $x^3 \ln^2 x$. Make sure you input that second expression in a way that makes sense for your computer system.

2. Calculate

$$\int \frac{x^2}{1+x^2}\,dx \qquad\qquad \int_0^\infty e^{-x^2}\,dx$$

3. Find the coefficient of $r^7$ in $(r^2+3r+4)^{10}$ using Taylor's formula, i.e., compute $\frac{p^{(7)}(0)}{7!}$.

## 5 Graphing

Another important component of these computer systems is their ability to draw pictures. This is especially valuable in multivariable calculus, where it is hard to draw and visualize things in 3 dimensions. Follow the directions on the website to start drawing graphs (particularly if you need to import a certain package to make it work) and then play around with it. Work with both explicit and implicit plotting expressions, change colors and viewing angles, and add multiple plots to the same axes. Once you are done, look at the following:

1. Plot the functions $f_1(x) = x^2$ and $f_2(x) = x^4$ on $[-1, 1]$ on a single set of axes.

2. Consider the function $f(x, y) = x^3 - 5xy^2$. We want to look at the graph of $f(x, y) = 7$, but we need to specify a plot window. Draw the graph for a variety of plot windows and pick one that looks good.

3. Now, we want to look in three dimensions. Draw a graph of $z = x^2+3y^2$ over $[-1, 1]\times[-1, 1]$.

4. Finally, draw a plot of the surface satisfying $x^2 + y^2 + z^2 = 1$.

## 6 Advanced Topics

Here, we look into more advanced things that aren't entirely necessary for these labs. They can make things look nicer and make the code run smoother, but you can get away without them. These are printing statements, conditional statements, and loops. Look at the website for more details on how to do this, then try the following:

1. Write a print statement that says "Hello World!"

2. Write a print statement that says "The coefficient of $r^7$ in $(r^2 + 3r + 4)^{10}$ is" followed by the value of this coefficient.

3. Create a for loop that counts from 1 to 10 and prints each number.

4. Modify the for loop so that it only prints even numbers in two ways, first by changing the loop, and secondly by adding an if statement inside of it.

5. Create a list/vector of 5 numbers, then loop through that list, printing the square of each of them. Your loop parameters should not involve the number 5, but get the number of times you need to iterate from the list/vector.