1. Introduction

The computations in Math 302 are usually constructed so as to allow the student to complete them by hand, finding a function or a number dealing with transcendental quantities for the answer. However, there are situations when we wish to employ the use of the computer to help us in our calculations. The reason for computer use is given as follows:

- In order to answer the posed question, we are required to perform an intermediate calculation which is tedious. If the intermediate calculation uses most of our time, we may be wise to do it via computer.
- Even though we emphasize graphing in class, sometimes you can get a better feel for a surface if you see the picture as rendered by an appropriate program. This can also help you to see if you are graphing the surface correctly.
- Sometimes by looking at the graph, we can gain some qualitative knowledge about the function, such as approximately where the maxima and minima are located, where it crosses the xy plane, etc.
- Some integrations are very difficult or impossible to do by hand. In this case, we can use the computer to find a reasonable approximation to the definite integral.

In order to accomplish the tasks indicated above, we will use a "computer algebra" system called Maple. It is similar in scope to Mathematica, and does some of the same tasks as Mathcad and Matlab, but in a different way. Maple is an interpreted language. It performs calculations as soon as you type them in. Thus, though Maple has a syntax that is used in running commands, most calculations can be done with only 2 or 3 maple commands.

This worksheet assumes that you are sitting at a computer with Maple running. Print this document, then find a lab computer that you can use. You should be able to run Maple9 from the start command or from an icon on the desktop. Once Maple9 is started, you should see a window with some icons along the top and a large white space. The white space is where you will type in commands. (All Maple commands in this document will be in typewriter font). Type

5+7;

in the screen. What do you get? This shows that you can use Maple as a glorified calculator if you want to. It even understands transcendental functions. Type
sin(Pi/6)*3;

Do you get what you expect? Notice that Maple expects you to end commands with a semi-colon. Type in a command without one. What happens? What happens if you use a colon instead?

I don't expect its worth the trouble to use Maple this way, but it illustrates the interpreted nature of the environment. In the remainder of the document, I will discuss three different tasks that will be useful to us in Math 302.

2. **Linear Algebra**

Virtually everything that we learn (except for theorems and proofs) in the Linear Algebra section can be done in Maple. Type the following in the Maple screen:

```maple
with(linalg);
```

This command loads the linear algebra package. Many commands are included, including those of defining matrices and vectors. Type the following:

```maple
A:=matrix(4,3,[1,2,3,4,5,6,7,8,9,10,11,12]);
```

This should assign to A a matrix with 4 rows and 3 columns, with the entries filled in row by row from the list. Now, you can use the matrix without redefining it each time. Type in the following:

```maple
B:=transpose(A);
C:=matrix(3,4,[1,1,2,3,4,5,5,6,6,6,6,6]);
matadd(B,C);
matadd(A,C);
```

Did you get what you expected? Look through the list of functions in the linear algebra package and see if you can guess by their name what they do.

**Homework question 1:** There are two direct ways to find the solution to a system of equations in the above list. Find them, and figure out how to use them to solve the following system:

\[
\begin{align*}
    x_1 + x_2 - x_3 + 2x_4 - 2x_5 &= 1 \\
    x_2 + x_3 + x_4 + x_5 + x_6 &= 1 \\
    x_1 + x_3 + x_4 + x_5 + x_6 &= 1 \\
    x_1 + x_2 + x_4 + x_5 + x_6 &= 1 \\
    x_1 + x_2 + x_3 + x_5 + x_6 &= 1 \\
    x_2 + x_5 - x_6 &= 1
\end{align*}
\]
Note that we can also calculate eigenvalues and eigenvectors of a square matrix. Type
\[
E := \text{multiply}(A, C);
\]
\[
eigenvals(D);
\]
Note that maple will give you the solution in closed form if it can. Type the command to find the eigenvalues of the coefficient matrix in question 1. Does it give you a useable answer? If you want a numerical answer, then encase the command with
\[
evalf();
\]
Try it with your last command. Does it give you better results?

3. Plotting

Another useful function of Maple (the one I use the most) is plotting of functions. Type
\[
\text{with(plots);}
\]
This will define a number of functions together. For example, you can plot any function with the plot command. Try
\[
\text{plot(sin(x), x=0..2*Pi);}
\]
\[
\text{plot([x, cos(x)], x=0..2*Pi);}
\]
\textbf{Homework question 2:} Find out how to plot the function \(z = x^2 + x - y^2\).
\textbf{Homework question 3:} The command to plot a surface that cannot be written as a function of \(x\) and \(y\) is called implicitplot. Find out how to use it and use it to plot a hyperboloid of one sheet and a hyperboloid of two sheets.

4. Integration

Finally, one of the places where we can take advantage of Maple is to use its integration facility. Note that this is much more than just regular integration. Maple can integrate almost as many problems as you can. Try
\[
\text{int(ln(x), x)}
\]
This is the maple command for
\[
\int \ln(x) \, dx.
\]
Notice that it doesn’t give you \(C\). You have to add that yourself. Try to find
\[
\int \sqrt{x^2 + 1} \, dx
\]
Does it always work? Try to find
\[ \int \sqrt{x^2 - 1} x^2 + 1 \, dx. \]

Notice that it gives it to you in terms of elliptic functions, which you probably don’t know about. This can be a problem.

If you want to find a definite integral, the command is similar. The integral for
\[ \int_1^e \ln(x) \, dx \]

can be calculated by the command
\[ \text{int} (\ln(x), x=1..\exp(1)); \]

**Homework question 4:** Use Maple to calculate
\[ \int_0^1 \sqrt{x^2 - 1} x^2 + 1 \, dx. \]

Not very satisfying is it. Figure out how to have Maple calculate the integral numerically. (Hint: Its an easy command.)

**Homework question 5:** Figure out how to use Maple to calculate double and triple integrals. Use your knowledge to calculate
\[ \iiint_V \sqrt{z - x^2 - y^2} \, dV \]

where \( V \) is the region between the surface
\[ x^2 + y^2 - z^2 - 2x - 2y = 0 \]

and the \( xy \) plane.