Introduction to MAPLE

How does a person make the lovely pictures in our Multivariable Calculus text?

There are computer programs ("environments") available on campus that you can use to visualize functions and do many kinds of calculations. I want to encourage you to learn and use such a tool.

The systems we have around the UI campus are: Maple, Mathematica, and Matlab. If you already know how to use one of these, you’re welcome to continue with that. If you want to learn [a new] one, I suggest Maple as being easiest to learn, and most widely available on campus. All the ITCs and Math/CS/Engineering Unix networks have Maple and Mathematica; Matlab is most popular among the engineers.
In this worksheet, I will introduce you to Maple. **THE WORKSHEET ENDS WITH A HOMEWORK PROBLEM.**

If you already know how to use Maple or one of the others, that’s great. If not, have the courage to just sit down at a computer, launch Maple (just bang on the icon that looks like a red maple leaf), and work along with this introduction.

**STEP 1. Simple calculations**

```maple
> 1+1;
2
```

The computer prompts us with the ">". Notice that after "1+1", the line ends with a semi-colon, ";". That tells Maple that we are finished telling it what to do, and we now want the computer to do something. Without the semi-colon, we can just keep typing, the writing will flow on to the next line, and we can enter expressions or commands that take more than one line. Of course, the computer won’t even know to read what we’ve written until we hit "return" or "enter".

Of course, the computer can do complicated arithmetic;

```maple
> sqrt(1+tan(3)^2)/ln(74)^(.65);
```

\[
\frac{\sqrt{1 + \tan(3)^2}}{\ln(74)^{.65}}
\]

All it did was acknowledge receipt of the input, In the case of "1+1", it went ahead and said, "2", but for complicated expressions, the computer may wait for us to tell it if we want a decimal value (rather, approximation to some number of decimal places), or we want to do something else.

If we want a decimal, we need to tell the computer to "evaluate xxxxx as a floating point number"; the command is "evalf".

```maple
> evalf(sqrt(1+tan(3)^2)/ln(74)^(.65));
```

```
3.911531725
```
If we want to use some letter, say "w", to denote the number, we have to tell the computer to "set w = xxxxx". We do that with a special version of "equals", namely ":=" (colon=equals).

\[
> w := \sqrt{1 + \tan(3)^2} / \ln(74)^.65; \\
> \text{evalf}(w);
\]

\[
-39.11531725
\]

(How am I writing these comments? You can toggle between "math" and "text" inputs - see the buttons at the top of the screen.)

Now let's do some calculus, Let's stick with Calc I ideas for now.

First, define a function \( f \) to be something interesting.

\[
> f := x^3;
\]

\[
f := x^3
\]

Here's how to differentiate \( f \) and integrate \( f \).

\[
> \text{diff}(f, x); \\
> \text{int}(f, x);
\]

\[
3 x^2 \\
\frac{1}{4} x^4
\]

For indefinite integrals, the computer loses a point on the test for forgetting "+c".

Here's how to enter a definite integral.

\[
> \text{int}(f, x=a..b); \\
\]

\[
\frac{1}{4} b^4 - \frac{1}{4} a^4
\]

Maple is good, but it can't work miracles. Some functions do not have antiderivatives that can be expressed in terms of the usual algebra, trig, and log/exp functions. If you give Maple such an integral, it will just punt and give you back the thing you asked for.
> \text{g}:=\text{exp}(\sin(x));
\quad g := e^{\sin(x)}

> \text{int}(g,x);
\quad \int e^{\sin(x)} \, dx

But even when the computer cannot antidifferentiate symbolically, it still can give you a numerical estimate of a definite integral. Use "evalf" to tell it to try this.

> \text{IWish}:=\text{int}(g,x=1..2);
\quad IWish := \int_{1}^{2} e^{\sin(x)} \, dx

> \text{evalf}(\text{IWish});
\quad 2.604661549

Note the syntax for telling Maple the limits of integration. In this, and other situations, when you need to tell the computer that some variable \(x\) runs from "a" to "b", you write "\(x=a..b\)" with \textbf{two} dots.

How about graphing? We use the command "plot".

> \text{f};
\quad x^3

> \text{plot}(\text{f},x=-2..2);
> g := \(e^{\sin(x)}\)

> plot(g, x=-2..2);

There are many options we can add to the \texttt{plot} command. To explore these, you want to ask Maple to show you its Help-Page for that command. Just enter "? plot".

> ?plot;

For example, suppose I want to add a title to the graph, and make the curve thicker.

> plot(g, x=-2..2, thickness=2, title='Jon\text{'}s graph');
Notice...thickness is specified by a number; to communicate a character string, you enclose it in single back-quotes. That may be the upper-left-most key on your keyboard - the back quote is not an apostrophe.

If you click on the graph on the screen, you will open a menu-bar at the top of the page [DO THIS FOR PRACTICE] that lets you change the appearance of the graph. The ease and power of graphics is one quick reason for learning to use the computer as opposed to relying on your old graphing calculator. (Of course it’s harder to carry around a pc.)

Now let’s see how to graph a function of two variables, $y = f(x,y)$.

First define the function.

$$ f := x \cos(\frac{y}{2}) / (1 + x^2) $$

$$ f := \frac{x \cos(\frac{1}{2} y)}{1 + x^2} $$

The command to plot in 3-dimensions is "plot3d". We tell the computer the three coordinates to plot, in this case, $x$, $y$, and $f(x,y)$. We also tell it which domain to use. The easiest way to do this is to tell it a numerical range for $x$ and a numerical range for $y$. 
Click on the picture. That does two things: First, it opens a menu-bar at the top of the screen that give you many many ways to modify how the graph is presented visually (but the menu tools won’t change the math - for that, you have to enter instructions at the keyboard). Second, you can rotate the picture in 3-dimensions. This is the "ooooooohh" moment!

```maple
> plot3d([x,y,f], x=-2..2, y=-1..1);
```

```maple
> with(plots):plot3d([x,y,x*cos(y/2)/(1+x^2)], x=-2..2, y=-2..2,
  > grid=[10,10], labels=[x,y,z], axes=boxed, orientation=[-10,81],
  > style=HIDDEN, lightmodel=light3, labels=['x-axis','y-axis','z']);
```
HOMEWORK PROBLEM

Use the computer (with Maple or Mathematica or Matlab, as you prefer) to graph the function
\[ z = \frac{1}{(x^2 + y^2 + 1)} \], for \( x \) and \( y \) each running from -3 to 3. Use your own name in the title of the graph, and have the computer put a box around the graph (either via the onscreen toolbar, or via the appropriate option for the plot3d command). You only need to hand in one or two pages, just enough to contain your command to do the plot, and the resulting picture.