640:152:72 **Part IV: playing with graphs on Maple** **10/12/2001**

The graphing capabilities of Maple explored here will probably seem rather familiar to you after your experience with graphing calculators and possibly other programs or devices. I won't discuss polar plots or parametric plots – but even those are generally available on hand-held calculators now. Maple does really lovely pictures with three-dimensional plots – but that's another course!

Let's begin with the simple command

*plot(x^3- 6*x +1);* **RET**

After the program responds, move back and alter your command to read

*plot(x^3- 6*x +1,x);* **RET**

Now a graph should be created.

Notice some things. For this kind of plot, Maple's default interval for x (what it assumes unless advised otherwise) is $[-10, 10]$. This may be what you want (suggestion: try graphing $\sqrt{x^2 - 100}$ and see what happens) but you may want more control. The *plot* command has a very large number of options. Read about them during the first free week you have by typing *help(plot)* and following all the references!

Let's look at the graph we have. By the way, when I am graphing, I tend to foul things up a great deal and I frequently end up with 5 or 10 graphs sitting around at the same time. Try to be neat and have everything labelled correctly. Of course, if the graphs hang around until you *quit* Maple entirely, they'll disappear also. But, meanwhile confusion will be increased. You can label things fairly easily. For example, the plot suggested above can be labelled with the command:

*plot(x^3- 6*x +1,x,title=‘cubic‘);* **RET**

Both quotes around the word "cubic" are single opening quotes, usually found in keyboards on the upper left together with tilde: ~.

Please look at the graph again. The vertical and horizontal axes are very differently scaled. Maple is trained to "autoscale" so it will **distort** the picture to fill the rectangular screen. I wrote that word very large because this feature has repeatedly surprised me, sometimes not pleasantly. Please put your cursor on the graph, and right click: go to Projection and select Constrained: that's the way the graph really looks, darn it: very, very, very thin. O.k.: relax. Let's draw another graph.

plot(sin(1/x),x=.001..1); **RET**

This graph is attempting to show some well-known misbehavior. $\lim_{x\to 0^+} \sin(\frac{1}{x})$ doesn't exist. So the graph should bounce around a lot when x is close to 0. It certainly seems to, but notice (by pure thought) that between each root or x-intercept of the function, there must be a place where the function is $+1$ and there must be a place where the function is -1. If you really look closely, the picture doesn't show this. Maple doesn't think about functions, it just plots points and connects the dots to produce the graph. Initial performance of *plot* is fairly simple-minded (more sophisticated alternatives can be specified). The plotted points can be seen by right clicking on the plot, going to Style and then selecting Point – you'll see just the computed points gotten from the function with no interpolated pixels darkened. If you increase the number of points to be plotted, you may get a better picture, but computation time can increase, sometimes a lot.

Here's another type of bad picture. You can get a nice curve if you type

plot(1/x,x=.01..1); **RET**

but things get bizarre and fairly useless if you change the domain to $[-1, 1]$ or to $[-2, 2]$. Just remember to be careful. Again, there are ways to help Maple avoid nasty errors with these kinds of discontinuities. The *help* screen for *plot* is long and has many entries in the SEE ALSO line. Another view of this curve, initially strange to me, can be gotten with

plot(1/x,x=-.1..(-.01)); **RET**

Again you should look at location of the vertical axis. Does the line segment displayed go through the origin?. Warning: if you want to plot from .01 to .03 note that more parentheses are needed – as in *x=.01..(.03)* – so that Maple will distinguish between the periods needed for a range of values (the ..'s) and the decimal point.

Try the command (but you may want to guess the result before completing the input):

plot({x^2,x^3},x=4..5); **RET**

Therefore you can plot collections of functions. This is sometimes useful.

Now I'd like you to define a function corresponding to $P(w) = \dfrac{e^w}{1+w^2}$ (you create the appropriate `Maple` command). Remember that `Maple` finds the derivative function of P with the character string *D(P)*. Then type this:

plot({P(t),D(P)(t)},t=-2..5); **RET**

As long as the variable (here, t) is used consistently, `Maple` will have no difficulty. Compare the two graphs. Where *D(P)* is 0 then P must have a horizontal tangent. Does this seem to occur? What happens to the graph of P when the graph of *D(P)* has a maximum?

Let's conclude by trying to find a root graphically.

*plot(x*ln(x)-sin(x),x=0..3);* **RET**

This function seems to have a root. There are options which will allow you to "zoom" in on the crossing, but can you just alter the domain several times and try to get the crossing located to the nearest ten-thousandth? You can check your answer with a numerical computation:

*fsolve(x*ln(x)-sin(x),x);* **RET**

reports 1.752677281, fairly close to where I thought the root was graphically. You can read about *fsolve* with the *help* command.

Continue to explore, please.

Question to test your `Maple` skill

Here's a calculus question:

a) Suppose A is a positive constant. Compute $\displaystyle\int_0^\infty (\sin Ax)\, e^{-x}\, dx$.

b) For which value of A is the integral largest? What is the value of that largest integral?

Try to answer this question only using `Maple`, with no paper computations allowed. If you want to try this yourself, don't read any further.

Hint I'd suggest *restart*ing first. Then compute the integral. Get a formula. Differentiate it with respect to A and set the result equal to 0 to get a maximum, etc.

Good luck, and thanks for reading with me. I hope you enjoyed this.

Disclaimer! Non-advertisement!! Important information!!!
Symbolic manipulation programs such as `Maple` are becoming increasingly available. Other popular programs with about the same capabilities are `Derive` and `Mathematica` and there are many special purpose programs in various fields of science, engineering, and mathematics which have extensive "intelligence" to analyze models. We're considering `Maple` here because Rutgers has a site license for this program, and it should be generally available on Rutgers systems. The specific instructions won't be the same from program to program, but many of the same ideas will be present. Students should expect to have a machine do tiresome or elaborate symbolic computations as well as numerical computations.