640:192:03 **Part IV: playing with graphs on `maple`** **10/14/96**

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 another screen should pop up with a graph.
There are some things to notice. For this kind of plot, `maple`'s default interval for x (what it assumes unless advised otherwise) is $[-10, 10]$ Maybe this is o.k. for you (suggestion: try graphing $\frac{1}{\sqrt{x^2-100}}$ and see what happens) but you may want more control. The *plot* command has a 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 on the screen at the same time. Try to be neater: get rid of those graphs you don't want with clicks on the appropriate lines reached through clicking File on each graph's window. Of course, if they hang around until you *quit* `maple` entirely, they'll disappear also. But, meanwhile confusion will be increased.
Again, look at the graph. Note that the vertical and horizontal axes are very differently scaled. But `maple` is trained to "autoscale" so it will **distort** the picture to fill the rectangular screen. I wrote that word so large because it's something that has repeatedly caused me confusion. Right now click on Projection and select "Constrained": that's the way it really looks, darn it: a very, very thin graph. O.k.: relax. Let's draw another graph.

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

This graph is attempting to draw close to some well-known misbehavior. $\lim_{x\to 0^+} \sin\left(\frac{1}{x}\right)$ 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. That doesn't seem to be the case. `maple` doesn't think. It plots points and connects the dots to produce the graph. The default performance of this is fairly simple-minded (more sophisticated alternatives can be specified) and the plotted points can be seen by clicking on Style and then on Point – you'll see just the computed points on the curve with no connections drawn. If you increase the number of points to be plotted, you will probably get a better picture, but computational time for the graph's creation increases.
Here's another type of bad picture. You can get a nice curve if you write

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

but things get increasingly bizarre if you change the domain from $[-1, 1]$ to $[-2, 2]$ to $[-3, 3]$ to $[-4, 4]$. 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.
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.
Define your own function and plot it: try to define $P(w) = \frac{e^w}{1+w^2}$ and then remember that `maple` finds the derivative function of P with the character string *D(P)*. Then try 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. What happens to the graph of P when the graph of *D(P)* has a maximum?

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Let's conclude by trying to find a root.

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

This function seems to have a root. If I put my computer mouse pointer "in" the picture, I see an arrow. I can move the arrow so that it "points" at the root, and push a mouse button (which one?). Then `maple` signals me by showing (on a white box in the upper left-had corner of the screen) that my mouse is pointing at X= 1.763,Y=0.001736 (your mouse may be slightly differently aligned – every time I do this the numbers change a bit! Let's check the picture with a numerical computation:

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

reports 1.75267781, fairly close to where I thought the root was graphically. You can, of course, read about *fsolve* with the *help* command.

Continue to explore, please.

Question to test your `maple` skill

I wanted to put the following question on a final examination for a large calculus course but a few sane human beings stopped me.

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

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

Of course I was composing all of my exams on a computer, and I always had a `maple` window open. I was dazed by the computational power so easily available. Luckily I was restrained. But can you answer my question **without** using anything other than `maple`? So no paper computations are allowed. 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.