Basics of Graphing
(number5.mws)

We have already used the basic plotting command sequence

plot(expression,x=a..b,optional stuff including the range on the dependent variable);

We have already seen that sometimes the key to getting a nice graph involves analyzing the expression to determine the appropriate range of values for x and y. Here we explore some more of MAPLE's plotting features. First we see how to plot multiple graphs on the same axes. The key thing to remember is that "curly braces", { }, are used to denote a set of objects (without regard to the ordering of the objects). For example, $\{x^2, x, -x^3\}$

denotes the set containging the functions x^2, x, $-x^3$. Try the MAPLE command

```
> plot({x^2-2,x^2-1,x^2, x^2+1},x=-5..5,y=-5..25);
```

You just asked MAPLE to plot the set of all 4 functions all at once. Of course we could name the set M

```
> M:={x^2-2,x^2-1,x^2, x^2+1};
```

and then simply plot M.

```
> plot(M,x=-5..5,y=-5..25);
```

MAPLE has a sequence generator command that will come in handy. Try the MAPLE command

```
> seq(x^2+i,i=-2..1);
```

Use this with the above plot command to obtain the same 4 graphs. (Note, you can copy and paste.)

```
> plot({seq(x^2+i,i=-2..1)},x=-5..5,y=-5..25);
```

1. Why dose the seqence need to be included in the curly braces?

Note that the graph of $x^2 + i$ eventually is entirely above the x-axis. Plot the graphs of $5\,x^3 - 5\,x + i$ for the values of i = -3, -2, -1, 0, 1,2,3 .

2. Is it possible to find any value of i so that the graph of $5\,x^3 - 5\,x + i$ is entirely above the x-axis? Explain your answer.

Sketch the graph of $\dfrac{x^2 - 1}{2\,x^3 + 3\,x - 2}$.

3. Where are the vertical asymptotes?
4. Is the vertical line really a part of the graph? Explain.

"Click" in the vicinity of the graph to frame the graph and to obtain a set of "buttons" associated with the "style" of the graph. Experiment with these "bottons" to see how they change the style of the graph. In the case of our above rational function, plotting only the data points might be appropriate. Include the graph of the same function plotted in this "points only" style. (Remember, you can copy and paste the MAPLE command.)

In each case below, graph the given set of functions on the same axes.

```
> {{sin(k x), k = -3 .. 3}}
```

5. Explain the effect of changing the parameter k on the graph of $y = k \sin(x)$.

```
> {sin(k x), k = 1 .. 4}
```

6. Explain the effect of changing the parameter k on the graph of $y = \sin(k x)$.

```
> {sin(x), sin(x + π/2), sin(x + π)}
```

7. Explain the effect of changing the parameter k on the graph of $y = \sin(x + k)$.

Sketch the graphs of the following functions: $\mathbf{e}^x \sin(x)$, $\sin(\ln(x))$, $\ln(\sin(x))$.

8. In each case plot the graph of the function and explain what the function is doing.
   a. y=abs(x) .

   b. y= floor(x) .

   c. y= Heaviside($t - 5$).

   d. y= piecewise($x \le 1, x^2, x - 1$).

We'll finish by considering some more sofisticated plotting procedures contained in a special plotting package loaded using the command

```
> with(plots);
[animate, animate3d, animatecurve, changecoords, complexplot, complexplot3d, conformal,
    contourplot, contourplot3d, coordplot, coordplot3d, cylinderplot, densityplot, display, display3d,
    fieldplot, fieldplot3d, gradplot, gradplot3d, implicitplot, implicitplot3d, inequal, listcontplot,
    listcontplot3d, listdensityplot, listplot, listplot3d, loglogplot, logplot, matrixplot, odeplot, pareto,
    pointplot, pointplot3d, polarplot, polygonplot, polygonplot3d, polyhedra_supported,
    polyhedraplot, replot, rootlocus, semilogplot, setoptions, setoptions3d, spacecurve,
    sparsematrixplot, sphereplot, surfdata, textplot, textplot3d, tubeplot]
```

Notice all the various commands contained in this package. Many of them should "ring a bell" with you.

The command for graphing implicit relations (the conic sections for example) is

implicitplot(relation in x and y, x=a..b,y=c..d, optional stuff)

9. On the same axes plot the graphs of the following conics $x^2 + i\,y^2 = 1$ for i = -3, -2, -1, 0, 1, 2, 3. On your printout indicate (by hand) which graph corresponds to each value of i.

10. On the same axes plot the graphs of the following circles $(x + k)^2 + y^2 = 1$ for i = -3, -2, -1, 0, 1,

2, 3.

On your printout indicate (by hand) which graph corresponds to each value of i. What is the effect on these circles

of changing the parameter k?

For the remainder of the exercises you must use the "on line" help with its accompanying examples to figure out how to sketch the desired graphs.

11. Sketch the 3-d plot, the 2-d contour plot, and the 3-d contour plot of each of the following functions (each on its own axes). You can "click" on the graph, "drag" it arround, and "double click" to redraw it with a different perspective. Experiment to get the "best" picture.

> $x^2 + 2\,y^2$

> $x^2 - 2\,y^2$

> $\cos(x^2 + y^2)$

12. Plot the graphs of the following 3-d implicit relations. Rotate as necessary to get a good view of the graph. (Choose reasonable values for the ranges of the x and y variables!)

> $x^2 + y^2 + 2\,z^2 = 1$

> $x^2 + y^2 - 2\,z^2 = 1$

> $x^2 + y^2 = 1$

13. Plot the following polar graphs in polar coordinates.

> $r = \sin(t)$

> $r = t$

> $r = i \sin(t)$ for i = 1..4 all on the same axis.

> $r = \sin(i\,t)$ for i = 1..4 all on the same axis.

>

14. Graph the following parametric equations in rectangular coordinates.

(This one is tricky. Use the appropriate plot command (2-d or 3-d) to plot the "vector" [x(t),y(t)] or [x(t,s),y(t,s),z(t,s)] .)

> $x = t,\ y = t^2$

> $x = \sin(t),\ y = \cos(t),\ z = t$

> $x = s + t,\ y = s^2,\ z = t^2 + s$

This graph is called a "surface". Does it look to you like a "smooth surface?"