Ÿ Lab 3: Plotting data and functions in Mathematics

Mathematica lets you display lists and tables of data graphically. You can also plot functions very easily. Graphics are often very useful for getting a more intuitive understanding of what is going on in a model. In this lab you will learn how to plot lists and functions using the commands

```
ListPlot@D
ListPlot3D@D
Plot@D
Plot3D@D
```

Ÿ Plotting lists

To start, consider a list of data, e.g.

```
l = 81, 1.2, 0.3, 3.1, 0.1, 4, 7.6, 10.1, 0.5, 1<
```

You can display this data using the command (note the use of upper and lower case letters in the command!)

```
ListPlot@lD
```

This command places the data in a diagram in which the entries n_i of the list are plotted on the y-axis, with i as the x-coordinate. So what you see in the above diagram are 10 dots with coordinates (i,n_i). Since single dots are not always very visible, it is sometimes better to display the data by joining adjacent dots through lines. This can be done using the command

```
ListPlot@l, PlotJoined ® TrueD
```

You can create lists of data using the command Table[]. For example,

```
Table@Random@D, 85<D
```

gives you a list of 5 numbers that are uniformly and randomly drawn in the interval [0,1]. You can plot this list using the command

```
ListPlot@%, PlotJoined -> TrueD
```

In the last command the argument % simply stand for the last Output produced by *Mathematica*, which in this case was the list of 5 random numbers.
By repeating these two commands (i.e. by reentering the command to create a list of 5 random numbers and then the command to plot them), you get a display of a different set of random numbers. Try! (Maybe you want to change the number of random numbers you want to display.)

There are many ways in which the command Table[] can be used to create lists. For example,

```
Table@Sqrt@xD, 8x, 0, 1, 0.2<D
```

gives you a list containing the square roots of the numbers 0, 0.2, 0.4, 0.6, 0.8 and 1, i.e. of the numbers obtained by starting out with 0 and adding 0.2 each time until you end up at 1 (that's what is specified by the part {x,0,1,0.2} in the second part of the above command). Check *Mathematica* Help for further information on the Table[] command.

You can also display data in 3 dimensions:
the command ListPlot3D[{{z_12,z_22,...{,{z_21,z_22,...},...}] makes a three-dimensional plot of the array of heights z_xy. For example, if

```
l = 881, 2<, 83, 4<, 85, 6<, 80, 0<<
```

then

```
ListPlot3D@lD
```

creates the surface obtained by joining the points with height 1 at (x,y)=(1,1), height 2 at (x,y)=(1,2), height 3 at (x,y)=(2,1), height 4 at (x,y)=(2,2), height 5 at (x,y)=31,), etc.

Ÿ Plotting functions

```
Plot@f, 8x, xmin, xmax<D
```

plots f as a function of x from xmin to xmax. Example:

```
Plot@Sin@xD, 8x, 0, Pi<D

Plot@8f1, f2, ...<, 8x, xmin, xmax<D
```

plots several functions together. Example:

```
Plot@8Sin@xD, Cos@xD, Exp@xD<, 8x, 0, Pi<D
```

Note that in the last example you can't see the whole graph of Exp[x] for the given domain of x-values. This is because *Mathematica* automatically chooses a range for the y-axis, and all values of the functions that fall outside this range are not plotted. However, you can simply change the range of y-values plotted by explicitly specifying the range of y-values plotted, which is done by using the option PlotRange->...:

```
Plot@8Sin@xD, Cos@xD, Exp@xD<, 8x, 0, Pi<, PlotRange ® 8-1, 20<D
```

There are many other ways in which you can change the look of graphics using various options specified in a similar manner as in the previous example. Check *Mathematica* Help for more information on available options.

You can also plot functions together by plotting each one of them separately and then using the Show[] command:

```
Plot@Sin@xD, 8x, 0, 1<D

Plot@Cos@xD, 8x, 0, 1<D

Show@%, %%D
```

3D surface plots of functions of 2 variables are obtained by using the command

```
Plot3D@f, 8x, xmin, xmax<, 8y, ymin, ymax<D
```

Example:

```
Plot3D@Sin@x * yD, 8x, 0, 3<, 8y, 0, 3<D
```

Again, there are a variety of options available to render the graphic output (see *Mathematica* Help)

Ÿ Exercises

- Create a list of the squares of the first 10 integers and plot this list.
  Use the option PlotJoined->True to get a continuous line, and compare this line to the
  a plot of the function f(x)=x^2 in the same range (i.e. for x in the range [1,10]).

- Plot the function tan(x) for x in the range [-3,3]. Do you see anything special?

- Plot the function sin(1/x) for x in the range [-1,1]. What's happening at x=0?
  (Use the PlotRange-> ... option and different ranges of x-values to zoom in!)

- Suppose the per capita reproductive output in a population of size N is given by
  f(N)=r/(1+N^b)

Plot this function for different values of the demographic parameters r and b. (Note: if you don't specify numeric values for these parameters, you cannot plot this function!! Try what happens if you don't specify these parameters...) What can you say about the influence of the parameters r and b on the reproductive output as a function of population size?

- 3D-Plot the function 10sin(x+sin(y)) for x and y in the range @- 10, 10D.

- 3D-Plot the function exp(-x^2-y_2) for x and y in the range @- 2, 2D.

```
PlotA8f1, f2, ...<, 8x, xmin, xmax<E
```