# Math 242
# MATHEMATICA Reference Sheet

*Mathematica* is a computational software package designed and developed by Stephen Wolfram. Wolfram Research, Inc., based here in Champaign, is one of the world's premier technical software companies. *Mathematica* provides software routines for numerical and symbolic computation, graphical visualization and data analysis.

This handout is **not** meant to be a comprehensive introduction to *Mathematica*. (The *Mathematica* Handbook is over 900 pages long!) However, it should help you to get started using *Mathematica*'s graphical subroutines to plot pictures of curves and surfaces in space.

You can access *Mathematica* in the Altgeld Hall PC lab (239 Altgeld), which is open from 8:00 to 4:00 Monday–Friday. The lab staff can help show you how to log on to the machines, run *Mathematica*, save and print *Mathematica* plots, etc. Therefore, this handout will only discuss the actual commands which you will need to enter to produce pictures.

1. **Entering** *Mathematica* **commands:** *Mathematica* runs as either a text-based interface or a notebook, so let us briefly discuss how to interact with the program in each case. In the text-based form, you enter commands and see *Mathematica*'s output at screen prompts. The input prompts (where you type in your commands) take the form `In[n]` and the corresponding output prompts (where *Mathematica*'s answers appear) take the form `Out[n]`. Here is a simple example:

   ```
   In[1] := 2 + 2
   Out[1] = 4
   ```

   In this example, the computer will automatically display the `In[1]` prompt. You type in $2 + 2$ and the computer returns `Out[1]=4`.

   When *Mathematica* is running in notebook form, it opens a new window (the notebook) for you to enter your commands in. In this case the `In[n]` prompt doesn't appear until *after* you have typed in your input. The keystroke to tell *Mathematica* to process your entry is SHIFT-RETURN. So in this case you would type $2 + 2$ SHIFT-RETURN and then *Mathematica* would return the answer as before.

   To exit *Mathematica*, type `Quit[]` at one of the input prompts. If you are running a notebook, there will be a **Quit** menu item which you can select.

2. **Graphing functions in** *Mathematica***:** First, let's discuss how to plot functions of a single variable $y = f(x)$. The *Mathematica* command `Plot[f[x],{x,xmin,xmax}]` will produce the graph of $y = f(x)$ for $\mathrm{x}_{\min} \leq x \leq \mathrm{x}_{\max}$. You can add various options to this command to change the way the output is shown, e.g.,

   ```
   Plot[f[x],{x,xmin,xmax},PlotRange->{ymin,ymax}]
   ```

   will restrict the picture so that the dependent variable $y$ lies between $\mathrm{y}_{\min}$ and $\mathrm{y}_{\max}$. *Mathematica*'s default setting makes the scale on the $x$-axis longer than that on the $y$-axis. To set equal scales on both axes, use the option `AspectRatio->1`.

You can also plot several functions on the same set of axes:

```
Plot[{f[x],g[x]},{x,xmin,xmax}].
```

Functions are entered using the usual mathematical syntax. Use a caret (^) for exponentials. Multiplication does *not* need to be specified explicitly, so you can write either $2 * x$ or $2x$ for the product of 2 and $x$. *Mathematica* knows all of the elementary mathematical functions such as logarithms, trig functions, etc. Type `Log[x]` for $\log(x)$, `Sin[x]` for $\sin(x)$, and so on. For $\pi$, use `Pi`.

Three-dimensional plots use the command `Plot3D`. Typing

```
Plot3D[f[x,y],{x,xmin,xmax},{y,ymin,ymax}]
```

will produce the graph of $z = f(x, y)$ for $\mathrm{x_{min}} \leq x \leq \mathrm{x_{max}}$ and $\mathrm{y_{min}} \leq y \leq \mathrm{y_{max}}$. Again, there are various options you can add to this command. Try experimenting with the option `ViewPoint->`$\{x_0, y_0, z_0\}$ for different choices of the point $(x_0, y_0, z_0)$.

*Mathematica* also does parametric plots (both 2D and 3D). The relevant commands are

```
ParametricPlot[{x[t],y[t]},{t,tmin,tmax}],

ParametricPlot3D[{x[t],y[t],z[t]},{t,tmin,tmax}]
```

and

```
ParametricPlot3D[{x[s,t],y[s,t],z[s,t]},{s,smin,smax},{t,tmin,tmax}].
```

These commands produce parametric plots of a curve in the plane, a curve in space, and a 2D surface in space respectively. The expressions $x[t]$, $y[t]$ and $z[t]$ (respectively, $x[s,t]$, $y[s,t]$ and $z[s,t]$) are the component functions of the parametrization and the function is plotted for $\mathrm{t_{min}} \leq t \leq \mathrm{t_{max}}$ (respectively, $\mathrm{s_{min}} \leq s \leq \mathrm{s_{max}}$ and $\mathrm{t_{min}} \leq t \leq \mathrm{t_{max}}$). Try the commands

```
ParametricPlot[{Cos[t],Sin[t]},{t,0,2Pi}]
```

and

```
ParametricPlot3D[{Sin[s]Cos[t],Sin[s]Sin[t],Cos[s]},{s,0,Pi},{t,0,2Pi}].
```

Do you recognize the resulting figures?

This should give you enough background information to begin experimenting with *Mathematica*. See if you can find a way to produce 3D plots of some of the quadric surfaces we discussed in section 12.6. (Hint: you may have to solve for one of the variables and plot several graphs on the same set of axes to get a reasonable picture. You can do it with a parametric plot, but it's not so easy to find the parametrizating functions $\{x[s,t], y[s,t], z[s,t]\}$ for most quadric surfaces.)