Exploring *Mathematica*
OAS skill module

To do this skill module, you should download and install the computer program *Mathematica*, which you'll hopefully find to be an extremely useful and fun tool for mathematics. It will do your homework for you, but it will also teach you a lot of new things and open some new, more interesting problems.

The best way to learn *Mathematica* is to use it to solve a problem that you have, but just playing around and browsing through the excellent documentation also helps. Your task in this skill module is to get acquainted with the program and to use it to do something interesting.

■ Getting Mathematica

Mathematica is usually very expensive, but our college (Natural Sciences) has purchased a license for every student. If you are not in Natural Sciences, you can find *Mathematica* in most computer labs on campus - in particular the Physics Microcomputer Lab and the Math Computer Lab, both on the seventh floor of RLM. To install it, go to https://www.ph.utexas.edu/software/ and follow the instructions there. You will have to log in with your UT EID, download a file and then go through some licensing hoops on the Wolfram Research website.
Hopefully this goes well. If it doesn't, get in touch with the UGTA in charge of this module - or seek a computer lab where the package is already installed - but really you want this on your own computer because it can be useful to you in the future.

■ Using Mathematica

So let's get started. This PDF file is a "printout" of a *Mathematica* notebook. Get rid of this PDF and download the original notebook. It is here: https://webspace.utexas.edu/ivp59/pub/laude/Mathematica%20skill%20module.nb
Select File -> New and create your own blank notebook. Now type in commands directly into the notebook. Press Shift+Enter to tell *Mathematica* to evalute them.

Mathematica is pretty sweet. You can do everything you could do on a calculator,

```
2 + 2
```

4

a scientific calculator,

```
ArcCos[Sin[Pi / 3]]
ArcCos[Sin[60 Degree]]
```
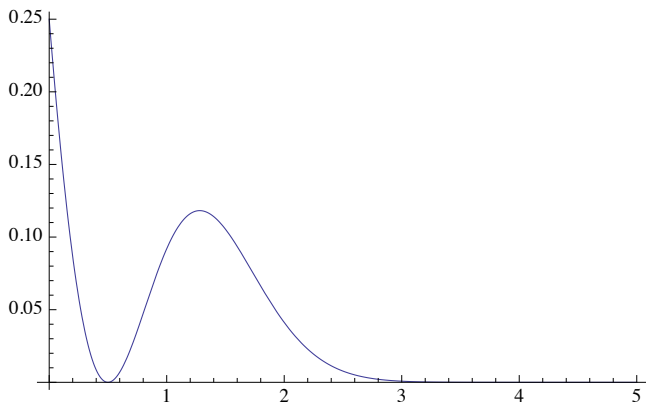
$\frac{\pi}{6}$

$\frac{\pi}{6}$

or a fancy symbolic integration graphing calculator,

```
Integrate[Exp[-x^2] * x^2, {x, 0, Infinity}]
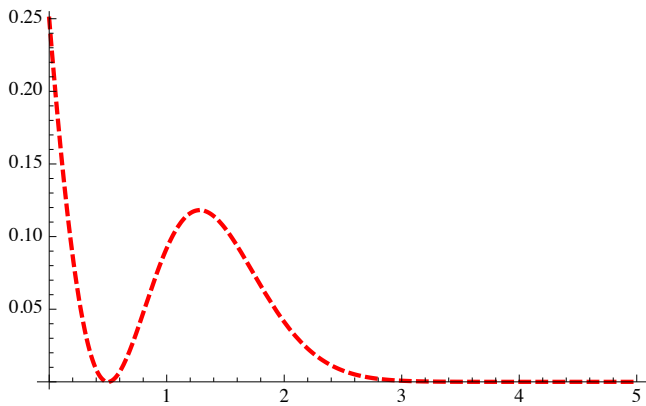```

$\frac{\sqrt{\pi}}{4}$

You can plot functions

```
Plot[Exp[-x^2] * (.5 - x)^2, {x, 0, 5}]
```
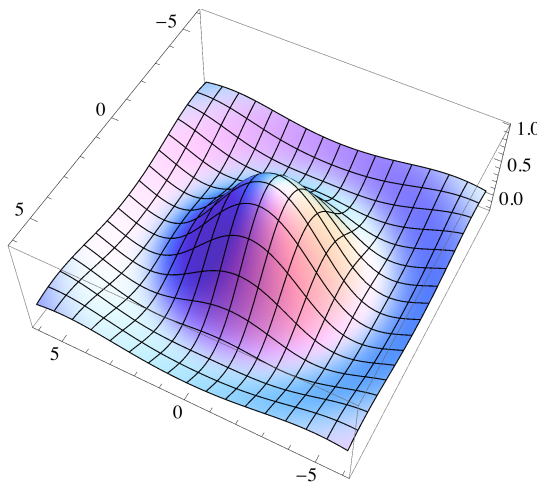


and you can tell the Plot function all sorts of nifty options to make your graph prettier. Most *Mathematica* functions accept arguments in the same way.

```
Plot[Exp[-x^2] * (.5 - x)^2, {x, 0, 5}, PlotRange → Full, PlotStyle → {Red, Thick, Dashed}]
```
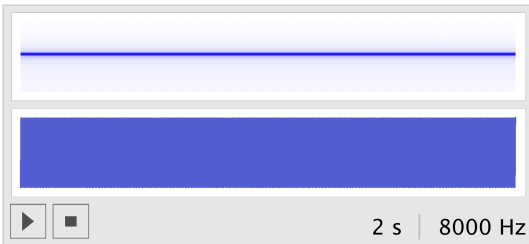


You can also plot functions of several variables:

```
Plot3D[Sinc[Sqrt[x^2 + y^2]], {x, -6, 6}, {y, -6, 6}, PlotPoints → 50, PlotRange → Full]
```


But all of this is just the beginning. *Mathematica* allows you to manipulate (and create) images and sounds. For example, you can type in an arbitrary waveform (in this case a middle A):

```
Play[Sin[440 × 2 Pi t], {t, 0, 2}]
```



```
image = ExampleData[{"TestImage", "Tree"}]
ColorConvert[image, "Grayscale"]
ImageAdjust[image, {.5, -.5}]
```

You can apply basically any *Mathematica* function to a list of items instead of just a single one. E.g.

```
Integrate[{1, x, x^2, x^3}, x]
```

$$\left\{x, \frac{x^2}{2}, \frac{x^3}{3}, \frac{x^4}{4}\right\}$$

To access an element of a given list, put its index into double square brackets

```
list = {"Hello", "world!", 44};
list[[2]]
```

```
world!
```

Check out the *Mathematica* documentation. It is a real gem - no one ever taught me how to do anything, I just searched the help file! Click "Help -> Documentation Center". From the title page you can follow the links to various examples or tutorials - or you can search for specific information. If you want information about a specific function, just type in its name. E.g. type in "Plot", then look around at the various settings that you can tweak to display your function well. The "Examples" section is usually beautiful, and it can give you some directions for exploring on your own. For even more information, open the "Scope" and "Applications" sections right under the examples. At the very bottom of the help page you will find links to related functions and tutorials.

Whatever you want to do with data or with mathematical functions, you can likely do it in *Mathematica*, and do it in a beautiful, illuminating way. This introduction has given you a very tiny taste of what you can do here. So your job now is to show off something interesting yourself. The way to do this is to get lost in the *Mathematica* Documentation Center. Type in some keywords, see what comes up, and see what strikes your fancy. I provide some suggestions at the end of this document.

This document itself is a *Mathematica* "notebook" - it combines text and commands and their results into one well-formatted presentation. What you will turn in at the end of this inquiry is a *Mathematica* notebook that has most of the commands that you played with and any neat results that came up - basically to prove that you have played around enough and that you've learned something new!

OK, now open the documentation center and start clicking around. Find some tutorials, find some intriguing examples and run with it. Come back in a few hours. Save everything you do in a Mathematica notebook; print it out; email it to your grader. If the dog eats it, just jot down some notes on what you did and let your grader know what you found most interesting.

If you are at a loss for where to start, which really, you shouldn't be, here are just some examples of things you could explore. In parentheses are the search terms you could use in the Documentation Center.

Solving differential equations - symbolically and numerically. (DSolve and NDSolve)

Spectral analysis of a noisy signal with the Fourier transform (Fourier)

Check out the tutorial on image manipulation. (Image Manipulation)

Check out the tutorial on generating sound. Make music! Test the frequency response of your speakers!

What does a torus look like? What if you intersect it with a Möbius strip? Now change the colors. Or, alternatively, define some function over its surface and integrate over the area. (?!?!) Yeah, really, you can do all of this.

Figure out how to export your facebook contacts in some *Mathematica* readable file. Now plot the graph. (Graph Visualization). What do you see? Can you move stuff around?

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