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Introduction to Plotting

4 minute read

In this lesson we will learn how to make beautiful plots using `Plots.jl`. You can find the code used in this lesson here (https://github.com/aurelio-amerio/techytok-examples/tree/master/lesson-plots)

In Julia there are many different libraries for plotting, for example `PyPlot.jl` (https://github.com/JuliaPy/PyPlot.jl), `GR.jl` (https://github.com/jheinen/GR.jl) and `Plotly.jl` (https://github.com/sglyon/PlotlyJS.jl). `Plots.jl` (https://github.com/JuliaPlots/Plots.jl) is a wrapper around all those library and exposes a clean and simple API (https://en.wikipedia.org/wiki/Application_programming_interface) for plotting. You can find all the back-ends available for `Plots.jl` here (https://docs.juliaplots.org/latest/backends/).

Installing `Plots.jl`

To install the library, write the following code:

```julia
using Pkg
Pkg.add("Plots")

using Plots
```

The first time it will take a while to download and compile `Plots`. The default back-end is `GR`, but if you desire you can change it, you can do so with a specific function for each back-end (see the documentation (https://docs.juliaplots.org/latest/backends/)). For example, if we desire to use `Plotly` we can call `plotly()` (which has a very nice interactive interface).

```julia
using Plots
plotly()
```

To revert back to the `GR` back-end, simply type

```julia
gr()
```

Plotting

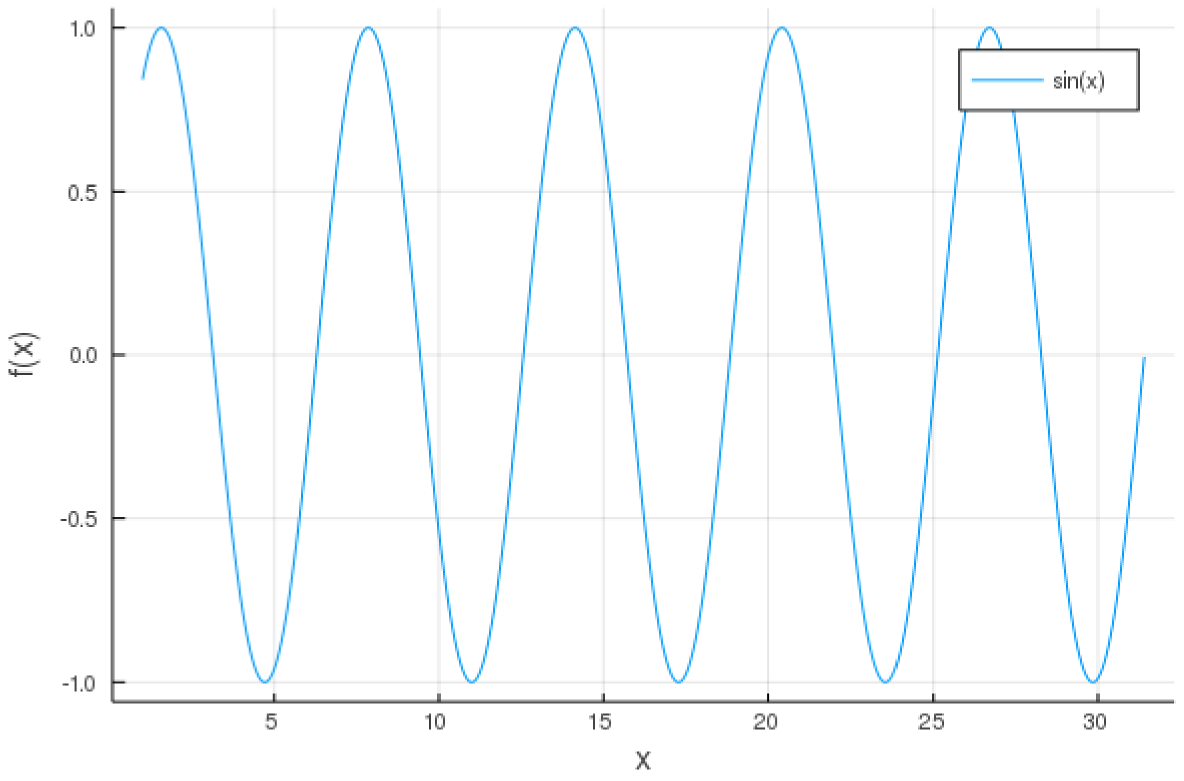
Let's make our first plot! We need to compute `x` and `y = f(x)`, for example let's plot the sine function:

```
1  using Plots
2
3  x = 1:0.01:10*π
4  y = sin.(x)
5
6  plot(x, y, label="sin(x)")
7  plot!(xlab="x", ylab="f(x)")
```

On line 3 we define `x` (a range from 1 to 10π with step 0.01) and at line 4 we compute `y = sin.(x)`. I want to remind you that the `.(x)` notation is called broadcasting and it is used to indicate to Julia that the function `sin` has to be computed for each element of `x`.

Line 6 is where all the magic happens: we `plot` `x` and `y=f(x)` and we assign a label to this plot, i.e. `sin(x)`. At line 7 we add some elements to the plot, using `plot!`. Remember that in Julia the `!` is appended to the name of functions which perform some modification: in this case `plot!` modifies the current plot. In particular, we add a label to the x-axis and the y-axis.

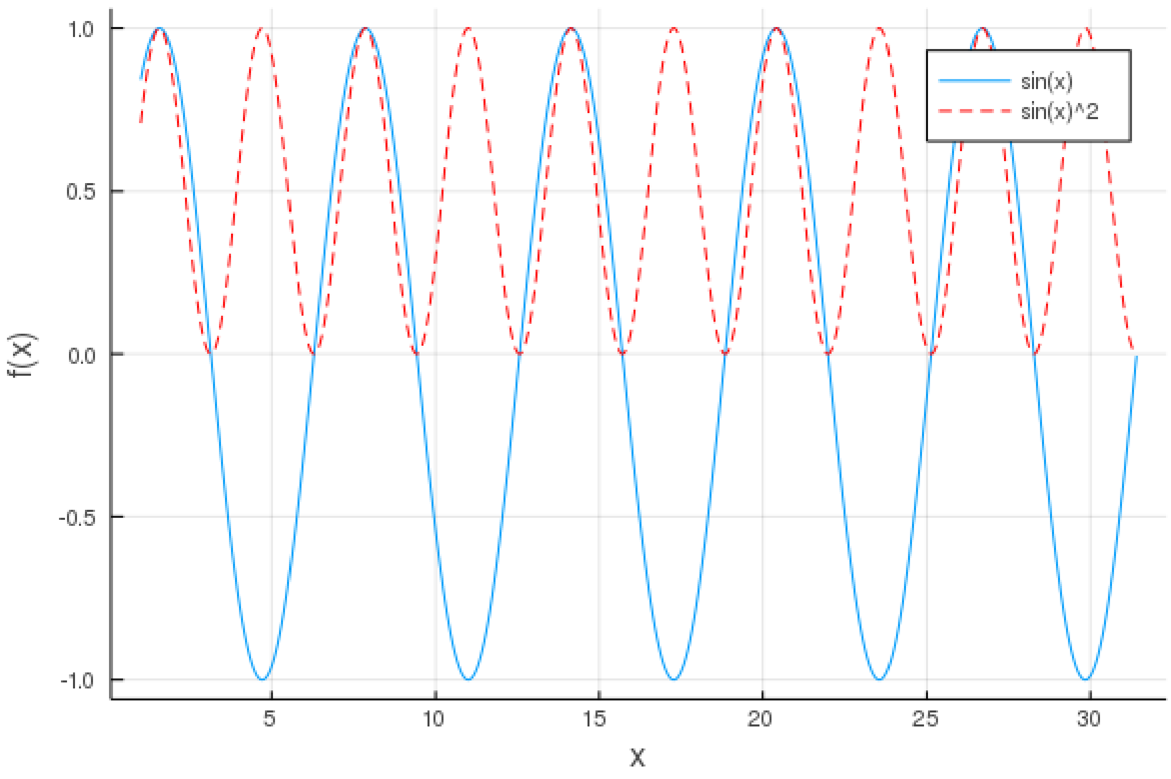
If you are using the REPL a windows should popup, on the contrary if you are using the Juno IDE a plot like the following should appear in the Plot window:



Let's add another curve to the plot:

```
1  y2=sin.(x).^2
2  plot!(x, y2, label="sin(x)^2", color=:red, line=:dash)
```

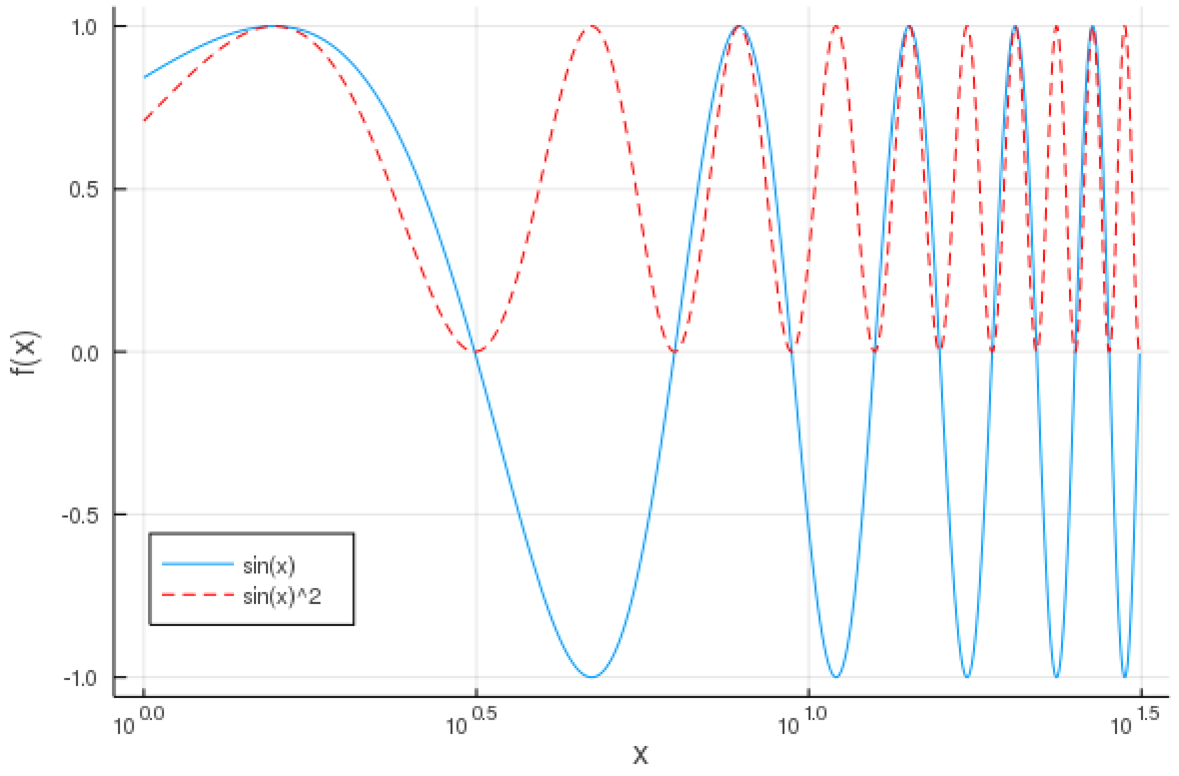
On line 2 you can see that we have specified the colour of the line and the linestyle (which is dashed in this case). You can find more information on the possible parameters at the official documentation (http://docs.juliaplots.org/latest/attributes/).



Now we can set the scale of the x-axis to be logarithmic and change the position of the legend, if we like:

```
1  xaxis!(:log10)
2  plot!(legend=:bottomleft)
3
4  savefig("img1c.png")
```

Furthermore on line 4 we can see how it is possible to save the current plot as a `.png` file.



Working with different back-ends

Different back-ends have different features. Up to now we have worked with `GR` , which is fast and has almost everything you may need. Since `GR` is a relatively new back-end, you may need to look at other back-ends for more customisation options. In this section, we will deal with `Plotly` and `PyPlot` .

Plotly

`Plotly` is a good solution if you want to have nice interactive plots.

To make a plot with `Plotly` , select the `plotly()` back-end and create a plot:

```
plotly()
x=1:0.1:3*π
y=1:0.1:3*π

xx = reshape([xi for xi in x for yj in y],  length(y), length(x))
yy = reshape([yj for xi in x for yj in y],  length(y), length(x))
zz = sin.(xx).*cos.(yy)
plot3d(xx,yy,zz, label=:none, st = :surface)
plot!(xlab="x", ylab="y", zlab="sin(x)*cos(y)")
savefig("img2")

```

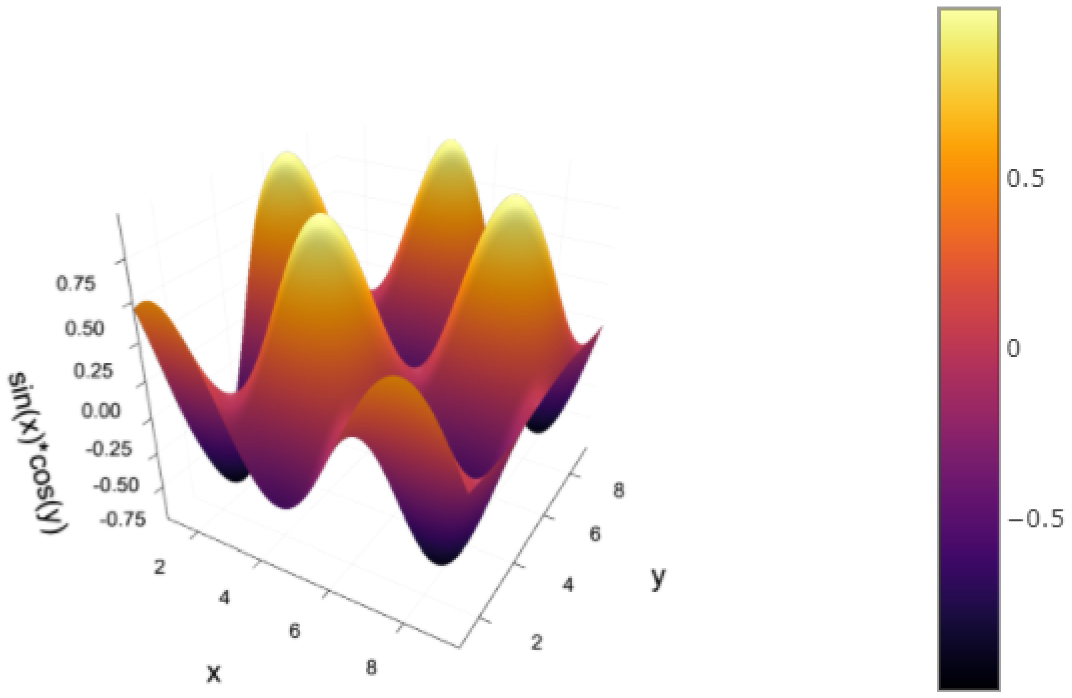
In this case the figure will be interactive and the saved figure will be an `html` page. Since `Plotly` is web-based it is possible to embed interactive plots in your website like the previous one:

This online interactive plot is obtained through the following code:

```
<iframe width="100%" height="450px" frameborder="0" scrolling="no"
src="/assets/images/2019/12/24b/img2.html"></iframe>
```

If you want to save a plot made with `Plotly` as an image, you need to install the `ORCA` package:

```
Pkg.add("ORCA")
using ORCA

savefig("img2.png")
```

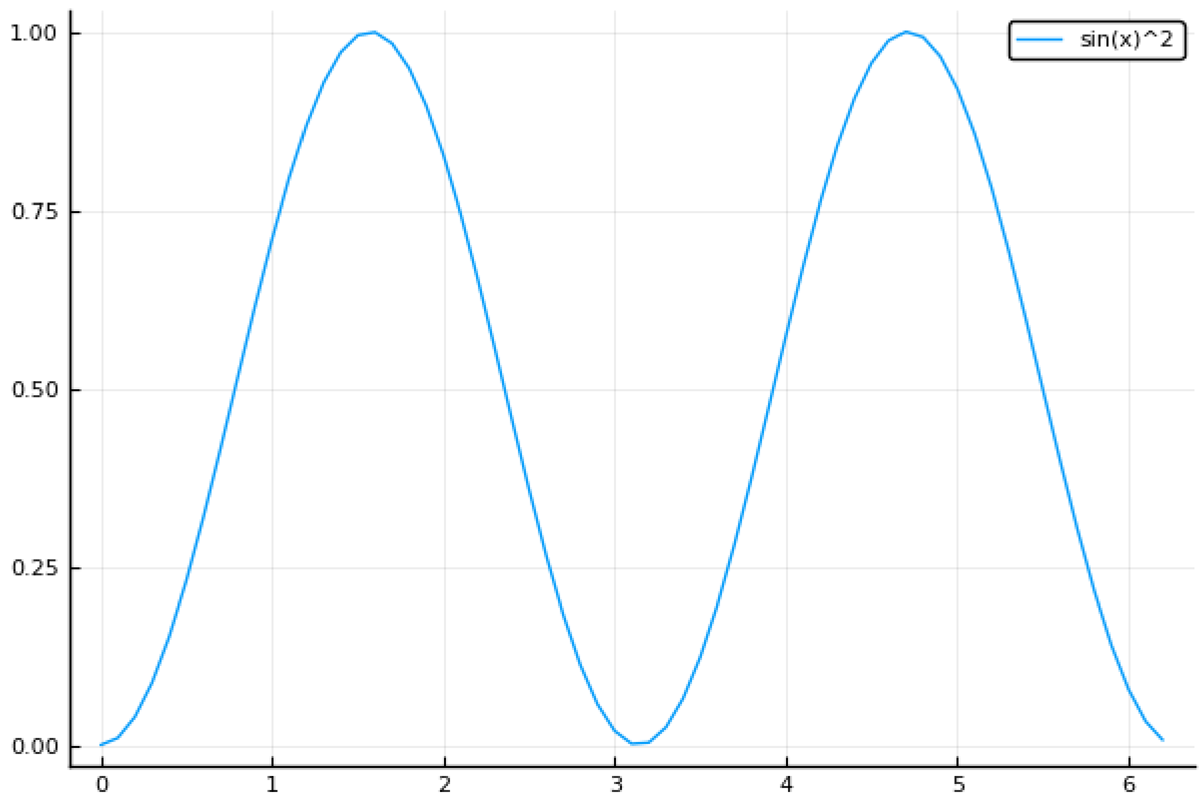


PyPlot

PyPlot is a Python library for plotting. It has many customisation capabilities with the downside that you need to first install python and configure Julia to interact with Python. In order to configure and install `PyCall`, the package required to interact with Python, please refer to this guide (https://techytok.com/lesson-interacting-with-python/).

In order to use the `PyCall` back-end, please type the following code:

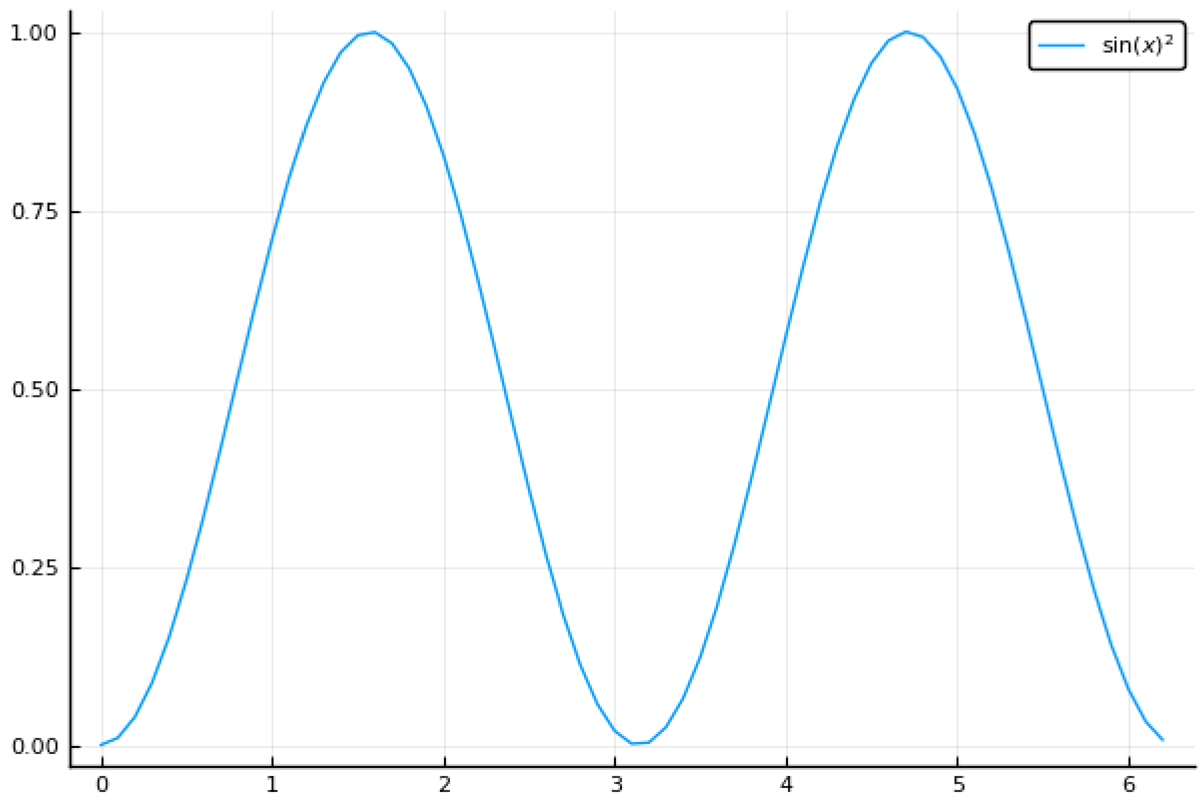
```julia
using Pkg
Pkg.add("PyPlot")
using Plots
pyplot()

x=0:0.1:2*π
y=sin.(x).^2

plot(x, y, label="sin(x)^2")
savefig("img3.png")
```



With the `PyPlot` back-end it is possible to use LaTeX in the labels (and axis labels) adding the `LaTeXStrings` package:

```
1  Pkg.add("LaTeXStrings")
2  using LaTeXStrings
3  
4  plot(x, y, label=L"$\sin(x)^2$")
5  savefig("img3b.png")
```

To create a LaTeX string, we have to write `L` before the string and put the LaTeX code inside `$`, as shown at line 4.



You can find more about matplotlib here (https://matplotlib.org/). Every function or property for matplotlib is available through `PyPlot.function_name` . If you are interested, take a look also to the `PyPlot.jl` (https://github.com/JuliaPy/PyPlot.jl) package.

Conclusions

We have learned how to make some nice plots using three different back-ends, each one has its pros and cons. To summarise:

- Use `GR` for fast “default” plotting.
- Use `Plotly` for interactive plotting.
- Use `PyPlot` if you need some of its customisation options.

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Thank you for reading this lesson and see you soon on TechyTok!

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