



Week 2: Fundamentals of Coding

STARFISH SCHOOL 2020

How is this going to work?

Building skills in Python and R

Throughout this and next lecture, we will balance teaching you skills in Python and R. Some of you may be expert in one but need brushing up in the other.

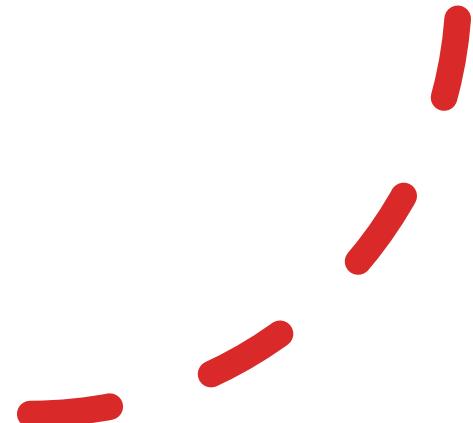
We think these balance each other well and will help you also see how the fundamentals underneath both (e.g. planning, pseudocode) work



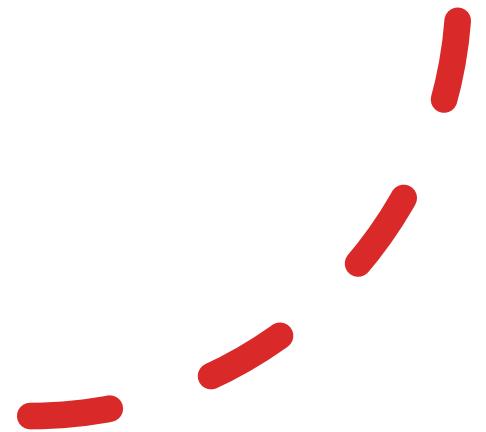
What is object-oriented programming anyway?

Rather than focusing only on functions or modules, the code is centered around the *objects* in the code (think: variables, lists, dictionaries) and their *properties* and *methods* that act on the objects.

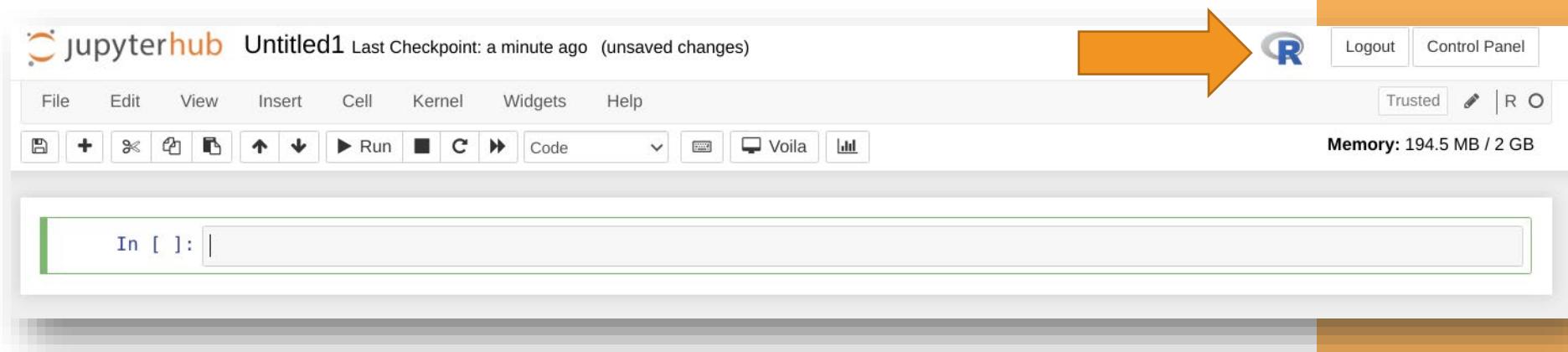
This can take some getting used to initially, but it helps code be more self-contained and readable/useable for future you!



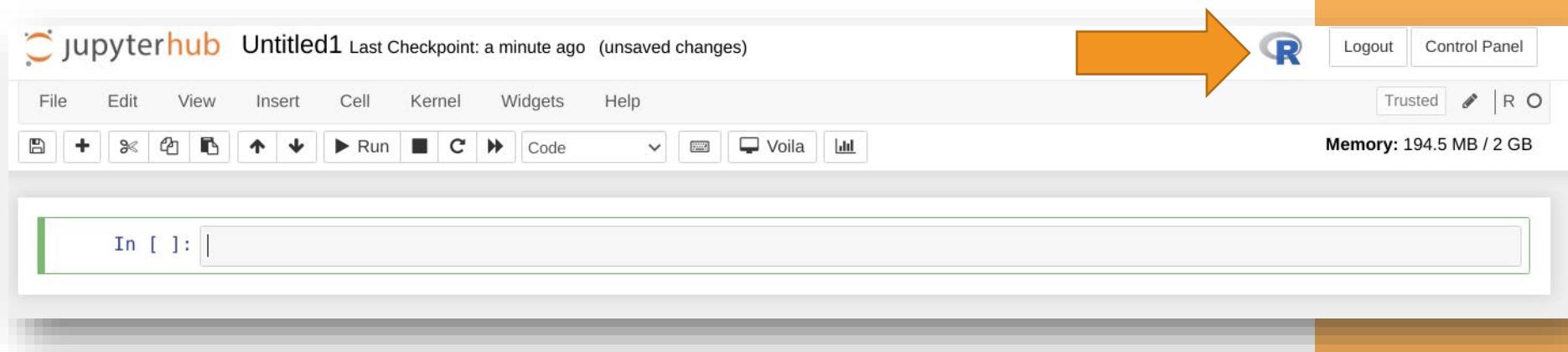
Interfaces



- This is a screenshot of a Jupyter Notebook running R

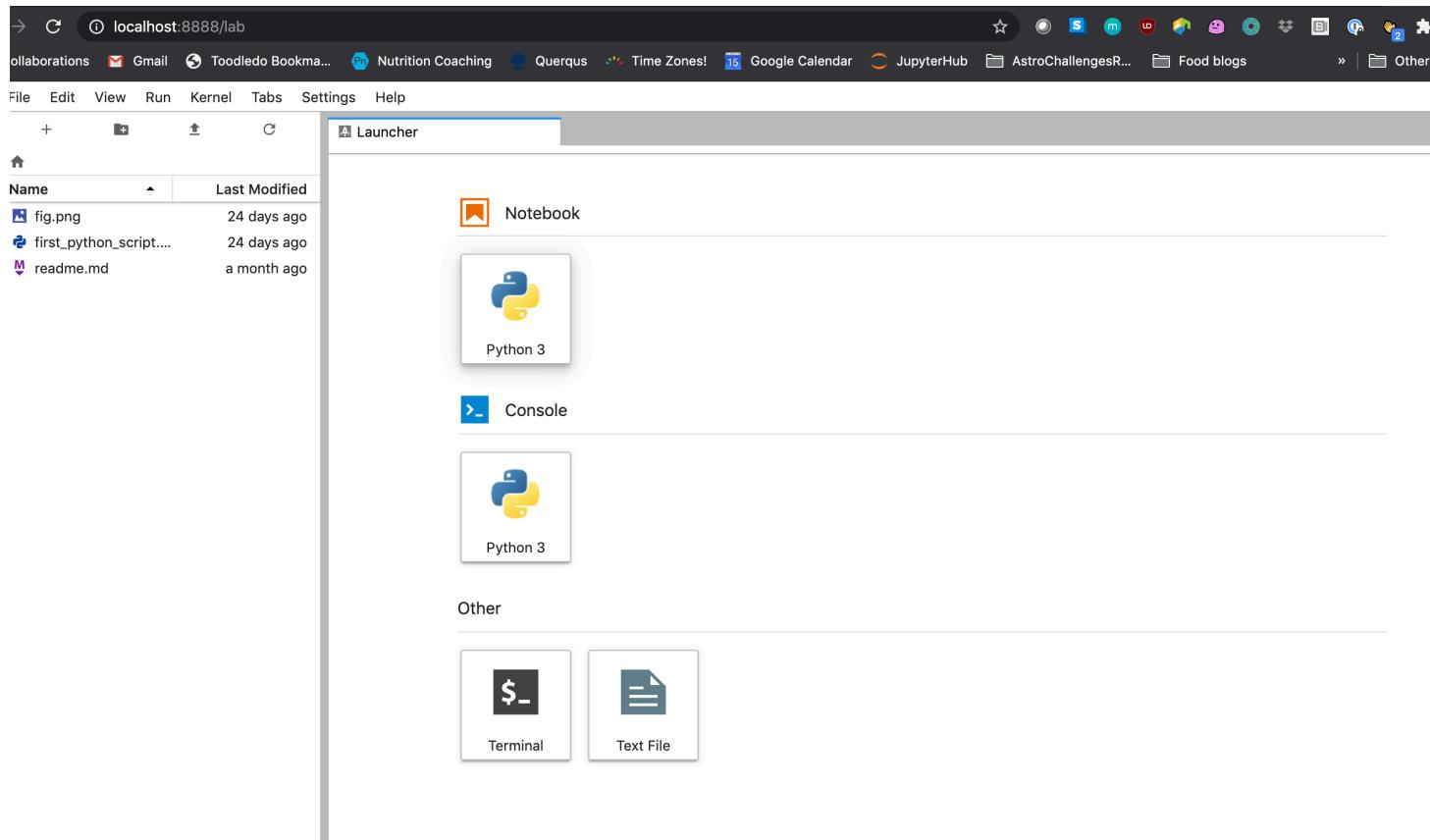


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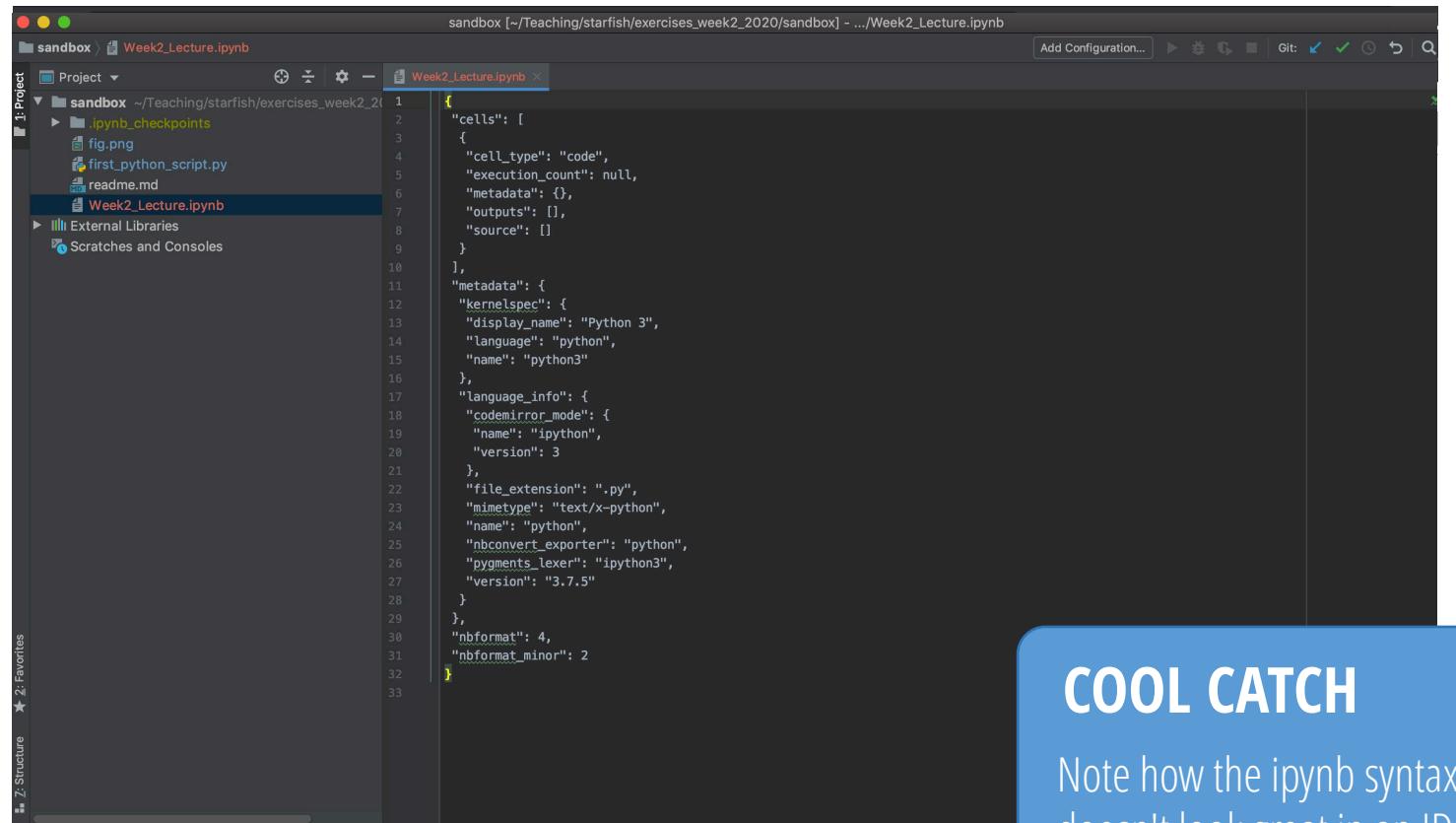


FUN FACT

JuPyteR is a play on the words *Julia*, *Python*, and *R*



- This is a screenshot of Jupyter Lab.
- You can use it to start a Jupyter notebook where we will add some code



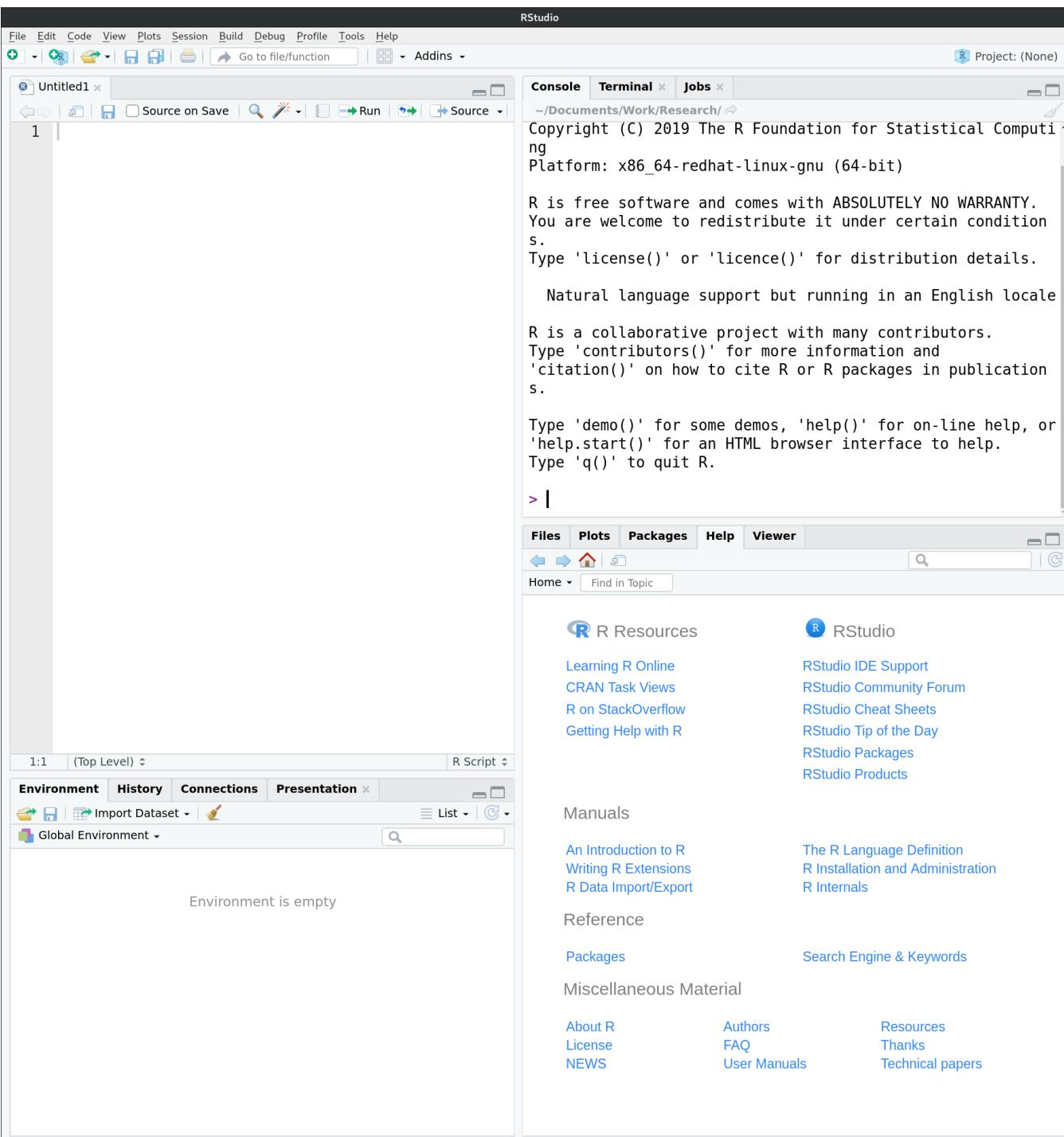
```
{  
    "cells": [  
        {  
            "cell_type": "code",  
            "execution_count": null,  
            "metadata": {},  
            "outputs": [],  
            "source": []  
        },  
        {"  
            "metadata": {  
                "kernelspec": {  
                    "display_name": "Python 3",  
                    "language": "python",  
                    "name": "python3"  
                },  
                "language_info": {  
                    "codemirror_mode": {  
                        "name": "ipython",  
                        "version": 3  
                    },  
                    "file_extension": ".py",  
                    "mimetype": "text/x-python",  
                    "name": "python",  
                    "nbconvert_exporter": "python",  
                    "pygments_lexer": "ipython3",  
                    "version": "3.7.5"  
                },  
                "nbformat": 4,  
                "nbformat_minor": 2  
            }  
        }  
    ]  
}
```

COOL CATCH

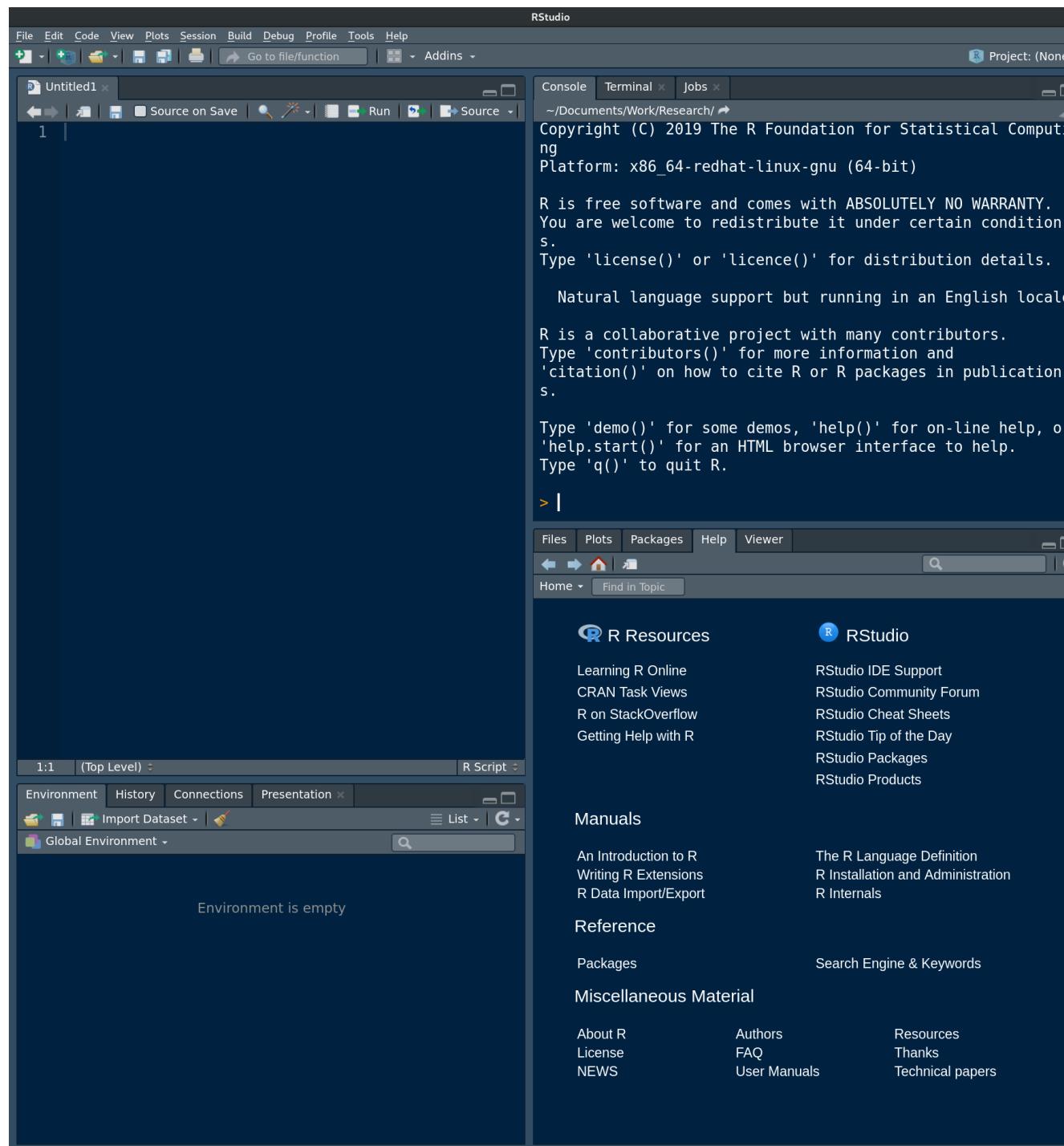
Note how the ipynb syntax doesn't look great in an IDE. It is better for scripts.



- You could also use an Integrated Development Environment (IDE) if you want to see your whole project all together.



- This is a screenshot of RStudio, an IDE for R
- You can use it to start/run R scripts, R projects, R Markdown documents, .. many options!



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HOT TIP

You can change the colour theme, typeface, panel layout, etc. ... lots of options!



Demo Time!
Quick Tour

RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function Addins

Untitled1 x Source on Save Run Source

Console Terminal Jobs

~/Documents/Work/Research/

Copyright (C) 2019 The R Foundation for Statistical Computing
Platform: x86_64-redhat-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

Files Plots Packages Help Viewer

Home Find in Topic

1:1 (Top Level) R Script

Environment History Connections Presentation Import Dataset List Global Environment

Environment is empty

R Resources RStudio

- Learning R Online
- CRAN Task Views
- R on StackOverflow
- Getting Help with R
- RStudio IDE Support
- RStudio Community Forum
- RStudio Cheat Sheets
- RStudio Tip of the Day
- RStudio Packages
- RStudio Products

Manuals

- An Introduction to R
- Writing R Extensions
- R Data Import/Export
- The R Language Definition
- R Installation and Administration
- R Internals

Reference

- Packages
- Miscellaneous Material
- Search Engine & Keywords

About R Authors Resources

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NEWS User Manuals Technical papers

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HOT TIP

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typeface, panel layout, etc. ... lots of
options!



How to begin

First you'll need to:

write some
pseudocode
(think of these as
blueprints for the
house)

customize your
space using
libraries/modules
(think of building
your house)

and then define
your variables
(who lives there)

Python 1

Modules and importing

- Adding lots of markdown to your notebooks really helps you keep things clean/organised and helps future you know what you are doing in the big picture rather than only comments (more line-by-line instructions)
- Modules can either those specified globally in your python path, or local files (turn your codes into modules to import!). Small codes are easier to read and good to reuse.
- Using an alias (e.g. np) is useful to keep modules organised

The screenshot shows a Jupyter Notebook interface with the following content:

```
[1]: # this is a comment
```

This is markdown. You can do cool things with it like $\partial f / \partial x = f'(x)$

```
[2]: import numpy as np
import matplotlib.pyplot as plt
```

```
[3]: plt.
```

A code completion dropdown menu is open over the line `plt.`, listing various methods and functions of the `matplotlib.pyplot` module. The listed items include:

Type	Method/Function	Description
i	absolute_import	instance
f	acorr	function
f	angle_spectrum	function
f	annotate	
c	Annotation	
c	Arrow	
f	arrow	
c	Artist	
c	AutoLocator	
f	autoscale	

HOT TIP

Tab completion works on imported modules



Installing Python Packages

- Anaconda makes this pretty easy – but it is important to also look up the package/dependenies
- Installing a python package:
 - Buying a book and putting it on the shelf
 - `conda install package`
- Where are my packages located?
 - Finding the spice rack
 - Conda list

Installers

`conda install` ?

linux-ppc64le	v4.0.1.post1
linux-64	v4.0.1.post1
win-32	v4.0.1.post1
osx-64	v4.0.1.post1
linux-32	v3.1
win-64	v4.0.1.post1

To install this package with conda run:

```
conda install -c anaconda astropy
```

Using conda packages

How can I configure or opt out of the Intel Math Kernel Library (MKL)?

For information on configuring and uninstalling MKL, see the [Anaconda MKL documentation](#).

How can I use Tkinter?

Make sure the conda package `tk` is installed:

```
conda list tk
```

If it is not installed, run:

```
conda install tk
```

Python programs can use TK!

There are standard locations:

- Unix (pure)¹: `prefix/lib/pythonX.Y/site-packages`
- Unix (non-pure): `exec-prefix/lib/pythonX.Y/site-packages`
- Windows: `prefix\lib\site-packages`

¹ *Pure* means that the module uses only Python code. *Non-pure* can contain C/C++ code as well.

`site-packages` is by default part of the Python *search path*, so modules installed there can be imported easily afterwards.

Some Basic Python Variables

Variable Type	What it is	Examples
int	An integer	2, -30, 3002
float	A real number, and some special values	0.0, 3.4, -2.3E33, nan, inf
string	A “string” of text	“a”, “abba”, “0.3”
bool	A True/False value	True, False

Some Basic Python Variables

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bool	A True/False value	True, False

HOT TIP

If you want to figure out what type of variable you have, use the `type()` command!



Some Basic Python Data Structures

Variable Type	What it is	Examples
list	A group of variables	["a", 4.3, True]
tuple	A group of variables (that you can't change)	("a", 4.3, True)
dict	A group of variables with keys to refer to them	{ "a": 3, "b": True, "x": "mama"}
set	A group of variables where every item is unique	{ 'a', 'b', 'c' }

Some Basic Python Data Structures

Variable Type	What it is	
list	A group of variables	["value", "value", "value"]
tuple	A group of variables (that you can't change)	("value", "value", "value")
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HOT TIP

We're going to go into "indexing" in depth next week, but for now, what you need to know is that the first item in a list/tuple can be grabbed using the index "0", second is "1". You can grab everything using ":"



Some Basic Python Data Structures

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dict	A group of variables with keys to refer to them	{ "a": 3, "b": True, "x": "mama"}
COOL CATCH All variables within a python data structure don't have to be the same variable type!	A group of variables where every item is unique	{ 'a', 'b', 'c' }

Functions, variables, docstrings in Python

- A few things to remember about function definitions in python

```
[6]: def renee_fun(x,y,z):
        """This function renee_fun takes in real number arguments x,y,z and returns and integer f = int(x^2+y^2+z^2)"""
        →
        f = x**2+y**2+z**2
        return int(f)

[5]: renee_fun(1.5,2.2,4.4)

[5]: 26
```

- Tab completion automatic in most browsers/IDE. Be careful coding without it!
- Three apostrophes = comment
- Make sure to return something from your function

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Demo Time!

Writing functions



R 1

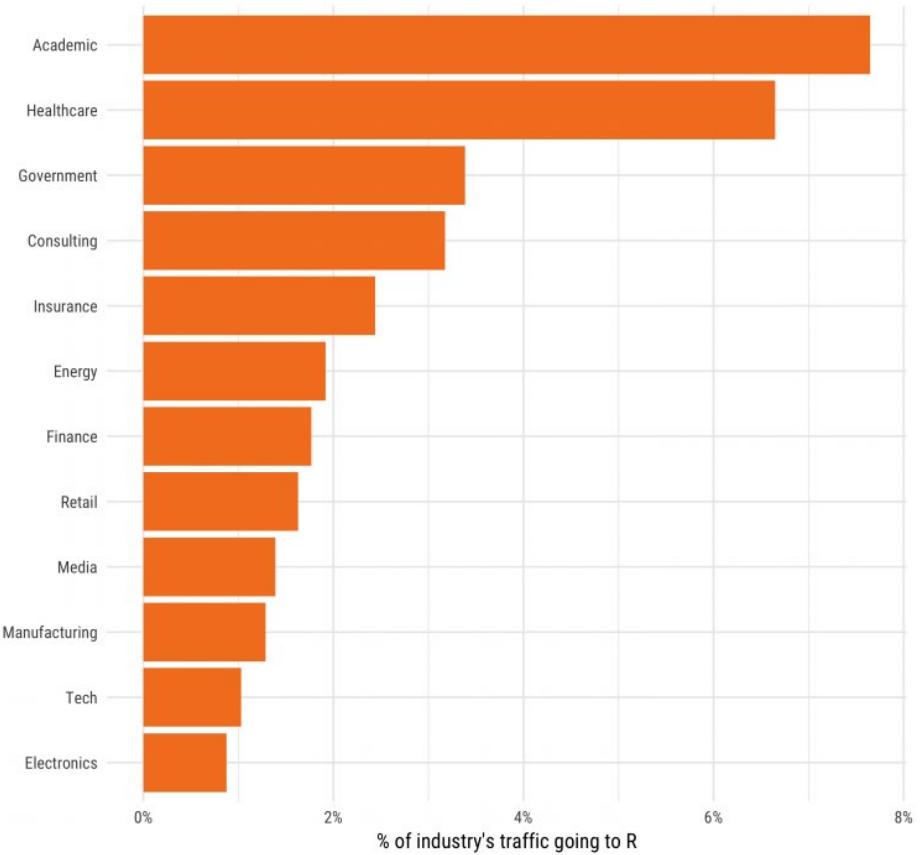
What is R? Who uses R?

- In academia: *statisticians, biostatisticians, genomics, social science, ecology, environmental science, actuarial science, ...*
- In industry: *government, healthcare, consulting, insurance, finance, ...*



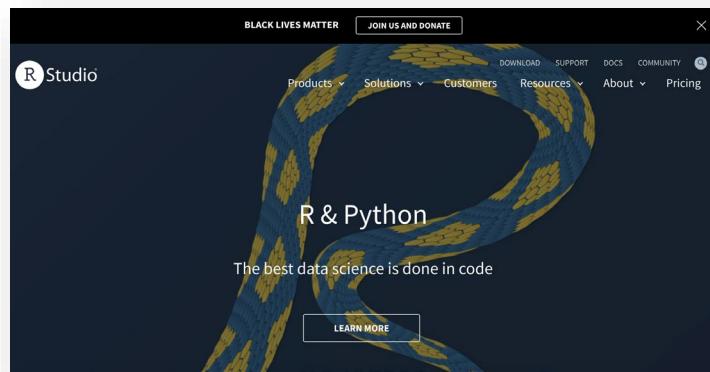
Visits to R by industry

Based on visits to Stack Overflow questions from the US/UK in January-August 2017.
The denominator in each is the total traffic from that industry.



stackoverflow.blog/2017/10/10/impressive-growth-r/

Communities



R Studio

BLACK LIVES MATTER JOIN US AND DONATE

Products Solutions Customers Resources About Pricing

R & Python

The best data science is done in code

LEARN MORE

Tidyverse

Packages Blog Learn Help Contribute



R packages for data science

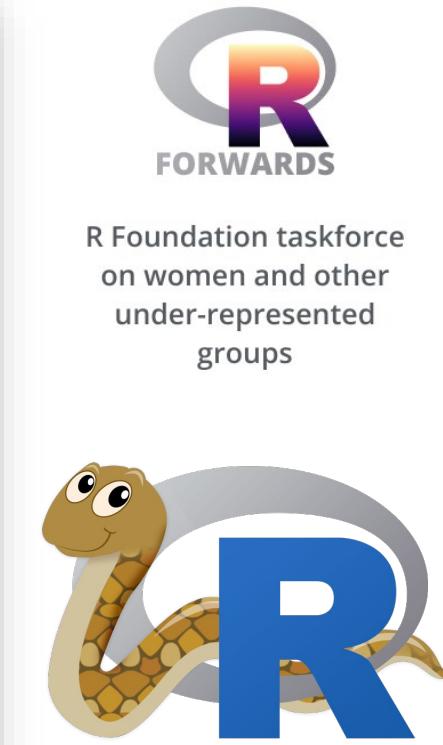
The tidyverse is an opinionated collection of R packages designed for data science. All packages share an underlying design philosophy, grammar, and data structures.

Install the complete tidyverse with:

```
install.packages("tidyverse")
```

Learn the tidyverse

See how the tidyverse makes data science faster, easier and more fun with "R for Data Science". Read it [online](#), buy the book or try another resource from the community.



R-LADIES GLOBAL

R-LADIES IS A WORLD-WIDE ORGANIZATION TO PROMOTE GENDER DIVERSITY IN THE R COMMUNITY

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MEETUP LOCATIONS

A complete list of all groups and meetups organised under R-Ladies globally may be found in the [R-Ladies organizational meetup](#), or check this awesome shiny dashboard!

BACK TO R-LADIES DASHBOARD



If you are interested in starting an R-Ladies meetup group in your city, or would like to find out more information about starting a meetup group, reach out at info@rladies.org.

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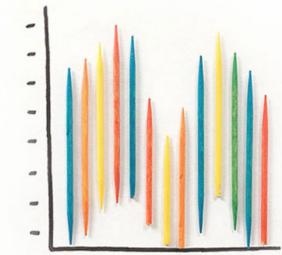
- DONATE TO R-LADIES -

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R Studio Education

Teaching A New Generation of R Users



Installing & Using R Packages

- R makes this relatively painless (because there are strict rules for packages submitted to the Comprehensive R Archive Network)
- Installing an R package:
 - Buying a book and putting it on the shelf
 - `install.packages("nameofpackage")`
- Using an R package:
 - Taking that book off the shelf and using it
 - `library("nameofpackage")`

```
Console Terminal x Jobs x
~/Documents/Work/Research/ ↗
>
>
>
> install.packages("ggplot2")
Installing package into '/home/Gwenny/R/x86_64-redhat-linux-gnu-library/3.6'
(as 'lib' is unspecified)
trying URL 'https://cran.rstudio.com/src/contrib/ggplot2_3.2.tar.gz'
Content type 'application/x-gzip' length 3054431 bytes (2.9 MB)
=====
downloaded 2.9 MB

* installing *source* package 'ggplot2' ...
```

```
zeroGrob                               html
*** copying figures
** building package indices
** installing vignettes
** testing if installed package can be loaded from temporary location
** testing if installed package can be loaded from final location
** testing if installed package keeps a record of temporary installation path
* DONE (ggplot2)

The downloaded source packages are in
  '/tmp/RtmpW6UgU0/downloaded_packages'
> library("ggplot2")
> |
```

Searching CRAN Task Views

Packages organized by subject and methodology

<https://cran.r-project.org/>



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CRAN Task Views

CRAN task views aim to provide some guidance which packages on CRAN are relevant for tasks related to a certain topic. They give a brief overview of the included packages and can be automatically installed using the [ctv](#) package. The views are intended to have a sharp focus so that it is sufficiently clear which packages should be included (or excluded) - and they are *not* meant to endorse the "best" packages for a given task.

- To automatically install the views, the [ctv](#) package needs to be installed, e.g., via `install.packages("ctv")` and then the views can be installed via `install.views` or `update.views` (where the latter only installs those packages are not installed and up-to-date), e.g.,
`ctv::install.views("Econometrics")`
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- The task views are maintained by volunteers. You can help them by suggesting packages that should be included in their task views. The contact e-mail addresses are listed on the individual task view pages.
- For general concerns regarding task views contact the [ctv](#) package maintainer.

Topics

Bayesian	Bayesian Inference
ChemPhys	Chemometrics and Computational Physics
ClinicalTrials	Clinical Trial Design, Monitoring, and Analysis
Cluster	Cluster Analysis & Finite Mixture Models
Databases	Databases with R
DifferentialEquations	Differential Equations
Distributions	Probability Distributions
Econometrics	Econometrics
Environmetrics	Analysis of Ecological and Environmental Data
ExperimentalDesign	Design of Experiments (DoE) & Analysis of Experimental Data
ExtremeValue	Extreme Value Analysis
Finance	Empirical Finance
FunctionalData	Functional Data Analysis
Genetics	Statistical Genetics
Graphics	Graphic Displays & Dynamic Graphics & Graphic Devices & Visualization
HighPerformanceComputing	High-Performance and Parallel Computing with R
Hydrology	Hydrological Data and Modeling
MachineLearning	Machine Learning & Statistical Learning
MedicalImaging	Medical Image Analysis
MetaAnalysis	Meta-Analysis
MissingData	Missing Data
ModelDeployment	Model Deployment with R
Multivariate	Multivariate Statistics
NaturalLanguageProcessing	Natural Language Processing
NumericalMathematics	Numerical Mathematics
OfficialStatistics	Official Statistics & Survey Methodology
Optimization	Optimization and Mathematical Programming
Pharmacokinetics	Analysis of Pharmacokinetic Data
Phylogenetics	Phylogenetics, Especially Comparative Methods
Psychometrics	Psychometric Models and Methods

Searching CRAN Task Views

Packages organized by subject and methodology

<https://cran.r-project.org/>



Demo Time!
Find a package on CRAN



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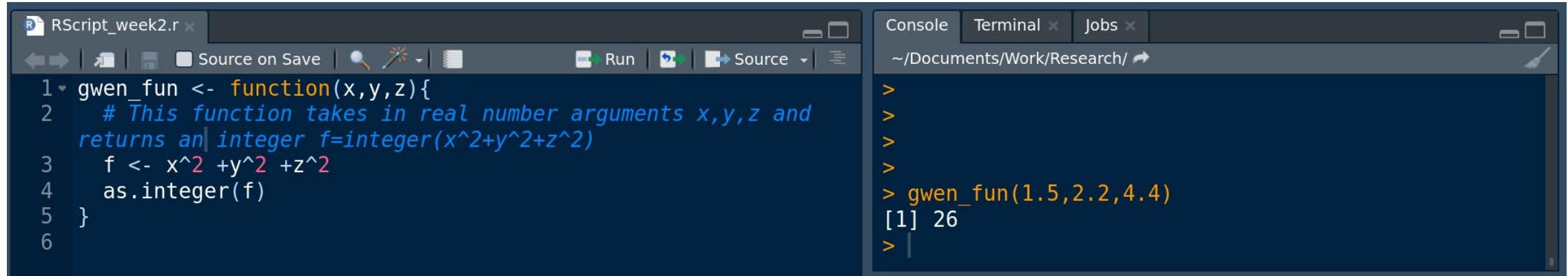
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ExtremeValue	Extreme Value Analysis
Finance	Empirical Finance
FunctionalData	Functional Data Analysis
Genetics	Statistical Genetics
Graphics	Graphic Displays & Dynamic Graphics & Graphic Devices & Visualization
HighPerformanceComputing	High-Performance and Parallel Computing with R
Hydrology	Hydrological Data and Modeling
MachineLearning	Machine Learning & Statistical Learning
MedicalImaging	Medical Image Analysis
MetaAnalysis	Meta-Analysis
MissingData	Missing Data
ModelDeployment	Model Deployment with R
Multivariate	Multivariate Statistics
NaturalLanguageProcessing	Natural Language Processing
NumericalMathematics	Numerical Mathematics
OfficialStatistics	Official Statistics & Survey Methodology
Optimization	Optimization and Mathematical Programming
Pharmacokinetics	Analysis of Pharmacokinetic Data
Phylogenetics	Phylogenetics, Especially Comparative Methods
Psychometrics	Psychometric Models and Methods

Functions and variables in R

- Defining functions



The screenshot shows the RStudio interface. On the left, the 'RScript_week2.r' script file is open, displaying the following R code:

```
1 gwen_fun <- function(x,y,z){  
2   # This function takes in real number arguments x,y,z and  
3   # returns an integer f=integer(x^2+y^2+z^2)  
4   f <- x^2 +y^2 +z^2  
5   as.integer(f)  
6 }
```

On the right, the 'Console' tab is active, showing the following session history:

```
>  
>  
>  
>  
>  
> gwen_fun(1.5,2.2,4.4)  
[1] 26  
>
```

- `#` precede any comments
- Tab completion works for packages, functions
- Just like in python, you have to actually return something!

Functions and variables in R

- Defining functions

HOT TIP

You can use an "arrow" or a = sign to define stuff. Either works!



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```
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4   f <- x^2 +y^2 +z^2  
5   as.integer(f)  
6 }
```

An orange arrow points from the word 'function' in the first line of the script to the word 'function' in the first line of the 'gwen_fun' definition in the 'HOT TIP' box. On the right, the 'Console' tab is active, showing the output of running the script:

```
>  
>  
>  
>  
> gwen_fun(1.5,2.2,4.4)  
[1] 26  
>
```

- # precede any comments
- Tab completion works for packages, functions
- Just like in python, you have to actually return something!

Mini-exercise 1

- Write a function (in Python and R) that takes as input your height (L_0), and computes your height L if you were travelling at $v = 0.3c$
- You may need to know the following equations for Lorentz contraction

$$L = L_0 / \gamma(v)$$

COOL CATCH

Don't forget that an input string will have a different type to a float or integer.



$$\gamma(v) \equiv \frac{1}{\sqrt{1 - v^2/c^2}}$$

Python 2

Input and output in Python

- Simple (numerical) reading from file using numpy loadtxt. Doesn't work well for mixed data -- which is most data.

```
filename = 'test.dat'  
data = np.loadtxt('test.dat', unpack=True)
```

- Pandas dataframe already loads file into dataframe

```
data = pd.read_csv('test.csv')  
data|
```

	x	data	y	data	colour
0	0.00	0.0000			blue
1	0.01	0.0001			green
2	0.02	0.0004			blue
3	0.03	0.0009			green
4	0.04	0.0016			green
5	0.05	0.0025			blue
6	0.06	0.0036			blue
7	0.07	0.0049			green
8	0.08	0.0064			blue

Input and output in Python

- Simple (numerical) writing to file using numpy savetxt. This is quick and dirty, but doesn't work well for mixed data -- which is most data.

```
x = np.logspace(-3,4,100)
y = x**2
np.savetxt('test.dat', np.transpose((x,y)), delimiter=' ')
```

- Pandas addalidme already todos nne into addalidme

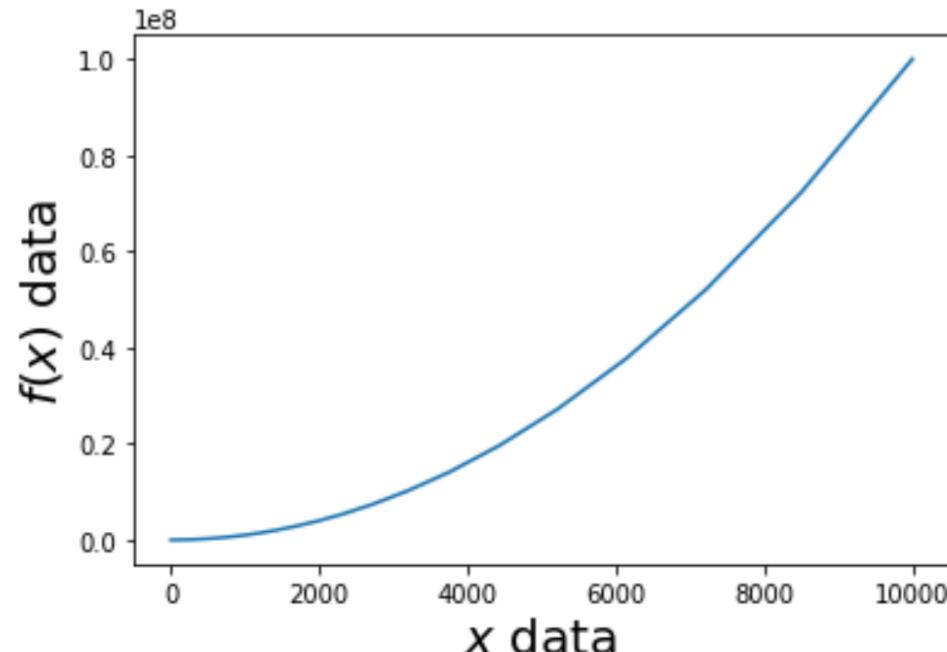
```
data = pd.read_csv('test.csv')
data.to_csv('test2.csv')
```

Plotting and visuals in Python

- Simplest and very basic thing for arrays/numerical data: matplotlib

```
filename = 'test.dat'
data = np.loadtxt('test.dat', unpack=True)
plt.plot(data[0],data[1])
plt.xlabel(r'$x$ data', fontsize=20)
plt.ylabel(r'$f(x)$ data', fontsize=20)
```

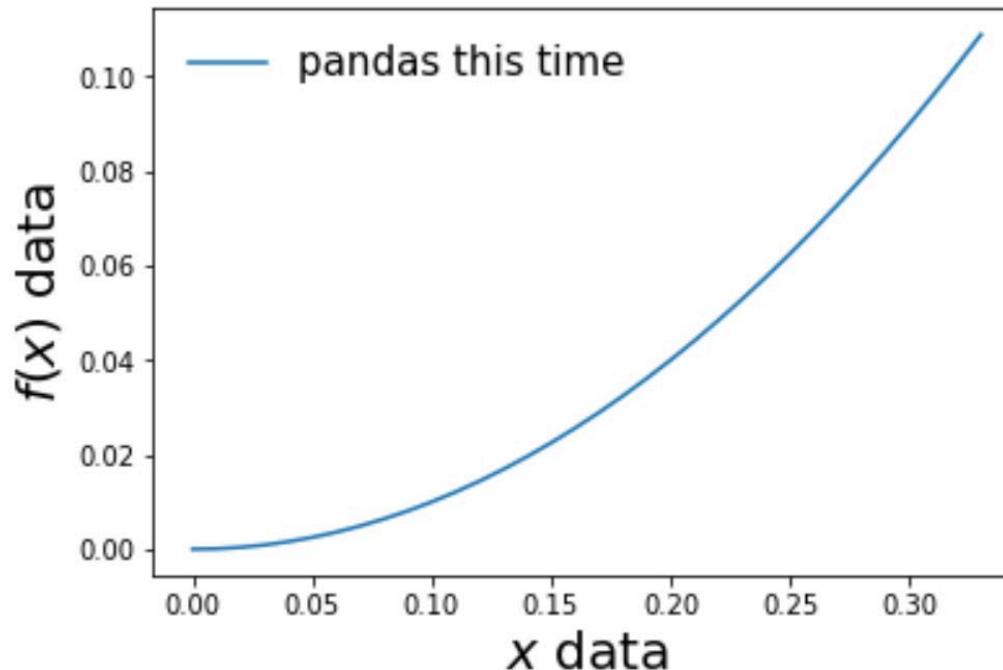
Text(0,0.5,'\$f(x)\$ data')



Plotting and visuals in Python

- Matplotlib also works for pandas dataframe

```
plt.plot(data['x data'],data['y data'], label='pandas this time')
plt.xlabel(r'$x$ data', fontsize=20)
plt.ylabel(r'$f(x)$ data', fontsize=20)
leg=plt.legend(loc='best', fontsize=15)
leg.draw_frame(False)
```



Random numbers

- Lots of ways to get random numbers

A screenshot of a Jupyter Notebook interface. A code cell at the bottom shows the following line:

```
[ ]: nums = np.random.r
```

An autocompletion dropdown menu is open over the word "r", listing several functions from the `np.random` module:

[]:	f rand	function
[]:	f randint	function
[]:	f randn	function
[]:	f random	function
[]:	f random_integers	function
[]:	f random_sample	function
[]:	f ranf	function
[]:	f rayleigh	function

Random numbers

- Mean, variance = 0,1 by default, easy to generate any distribution

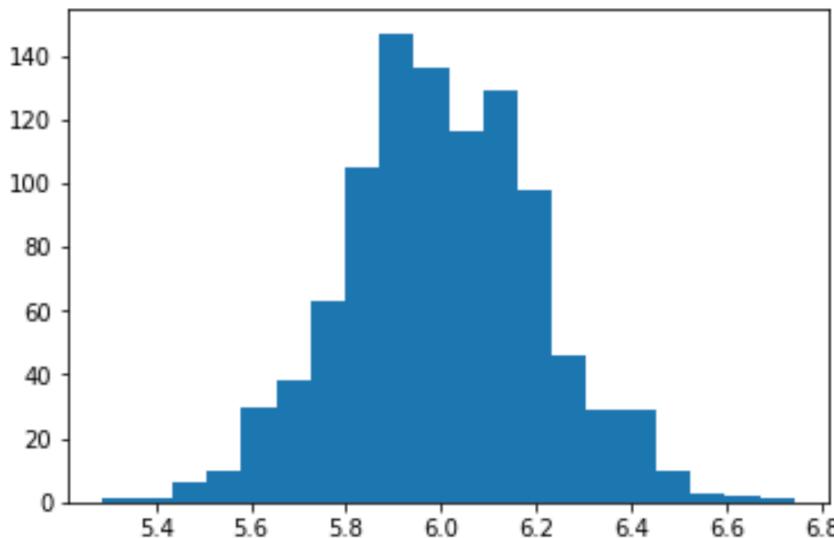
HOT TIP

Note the difference between matplotlib and numpy histograms

```
nums = 6 + 0.2* np.random.randn(1000)|
```

```
: np.histogram(nums)
: plt.hist(nums,20)
```

```
: (array([ 1.,  1.,  6., 10., 30., 38., 63., 105., 147., 136., 116.,
:        129., 98., 46., 29., 29., 10., 3., 2., 1.]),
: array([5.28869683, 5.36138985, 5.43408286, 5.50677587, 5.57946888,
:        5.65216189, 5.72485491, 5.79754792, 5.87024093, 5.94293394,
:        6.01562695, 6.08831997, 6.16101298, 6.23370599, 6.306399 ,
:        6.37909202, 6.45178503, 6.52447804, 6.59717105, 6.66986406,
:        6.74255708]),
: <a list of 20 Patch objects>)
```



Python Tips

HOT TIP

Figuring out how to be efficient in your search terms makes a **HUGE** difference – also know which python version to include helps!

stackoverflow About Products For Teams [python]

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Questions tagged [python]

Python is a multi-paradigm, dynamically typed, multipurpose programming language. It is designed to be easy to understand, and use, and enforce a clean and uniform syntax. Please note that Python 2 is of 01-2020. Still, for version-specific Python questions, add the [python-2.7] or [python-3.x] tag. If you are using a library (e.g. Jython, PyPy, Pandas, Numpy), please include it in the tags.

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How to resolve issue with Python 3 modules not building in cross-compiling
I want to cross-compile python 3.7 for my SoC-FPGA ARM board since its OS is completely different. I have binaries and libs to compile the python on it so the only option is to cross-compile it. As far as I know, there is no way to do this with the standard Python source code. I am trying to solve https://www.hackerearth.com/practice/data-structures/arrays/1-dimensional/problems/algorithm/bracket-sequence-1-40eab940/submissions/ in python. Its showing 0 answers and 4 views.
[python](#) [linux](#) [cross-compiling](#)

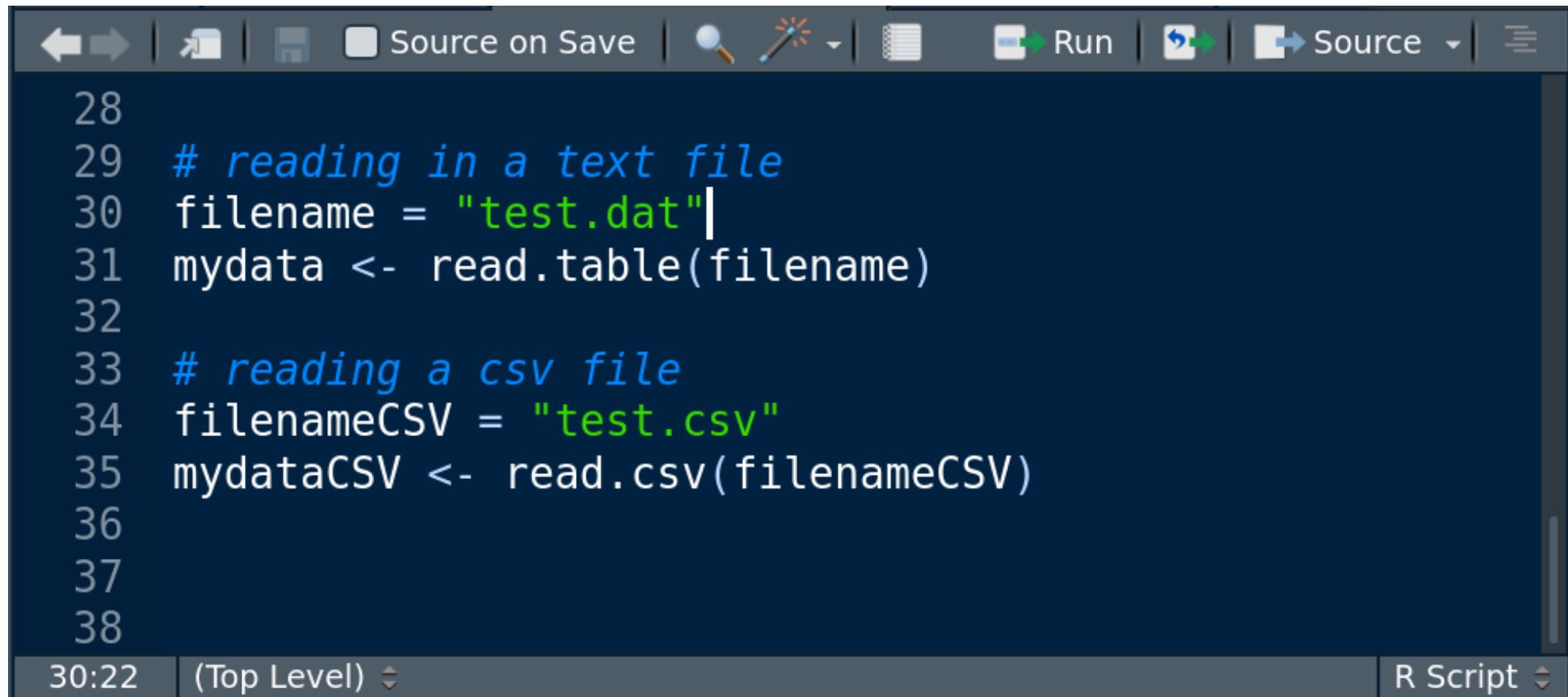
Bracket Question in Python . Solve in Minimum Time and Space?
I am trying to solve https://www.hackerearth.com/practice/data-structures/arrays/1-dimensional/problems/algorithm/bracket-sequence-1-40eab940/submissions/ in python. Its showing 0 answers and 5 views.
[python](#) [string](#) [algorithm](#) [data-structures](#) [array-algorithms](#)

How to implement regularization constraints on only part of the training model using python

R 2

Input and Output into R

- Lots of options for reading in data in basic R (i.e. without extra packages)



The screenshot shows the RStudio interface with the following details:

- Toolbar:** Includes icons for back, forward, file, source on save, search, and run.
- Code Editor:** Displays R code for reading files. The code is numbered from 28 to 38.
 - Line 28: `28`
 - Line 29: `29 # reading in a text file`
 - Line 30: `30 filename = "test.dat"`
 - Line 31: `31 mydata <- read.table(filename)`
 - Line 32: `32`
 - Line 33: `33 # reading a csv file`
 - Line 34: `34 filenameCSV = "test.csv"`
 - Line 35: `35 mydataCSV <- read.csv(filenameCSV)`
 - Line 36: `36`
 - Line 37: `37`
 - Line 38: `38`
- Status Bar:** Shows "30:22" and "(Top Level)" on the left, and "R Script" on the right.

Input and Output into R

- Lots of options for reading in data in basic R (i.e. without extra packages)

The screenshot shows an RStudio interface with the following code in the script pane:

```
28
29 # reading in a text file
30 filename = "test.dat"
31 mydata <- read.table(filename)
32
33 # reading a csv file
34 filenameCSV = "test.csv"
35 mydataCSV <- read.csv(filenameCSV)
36
37
38
```

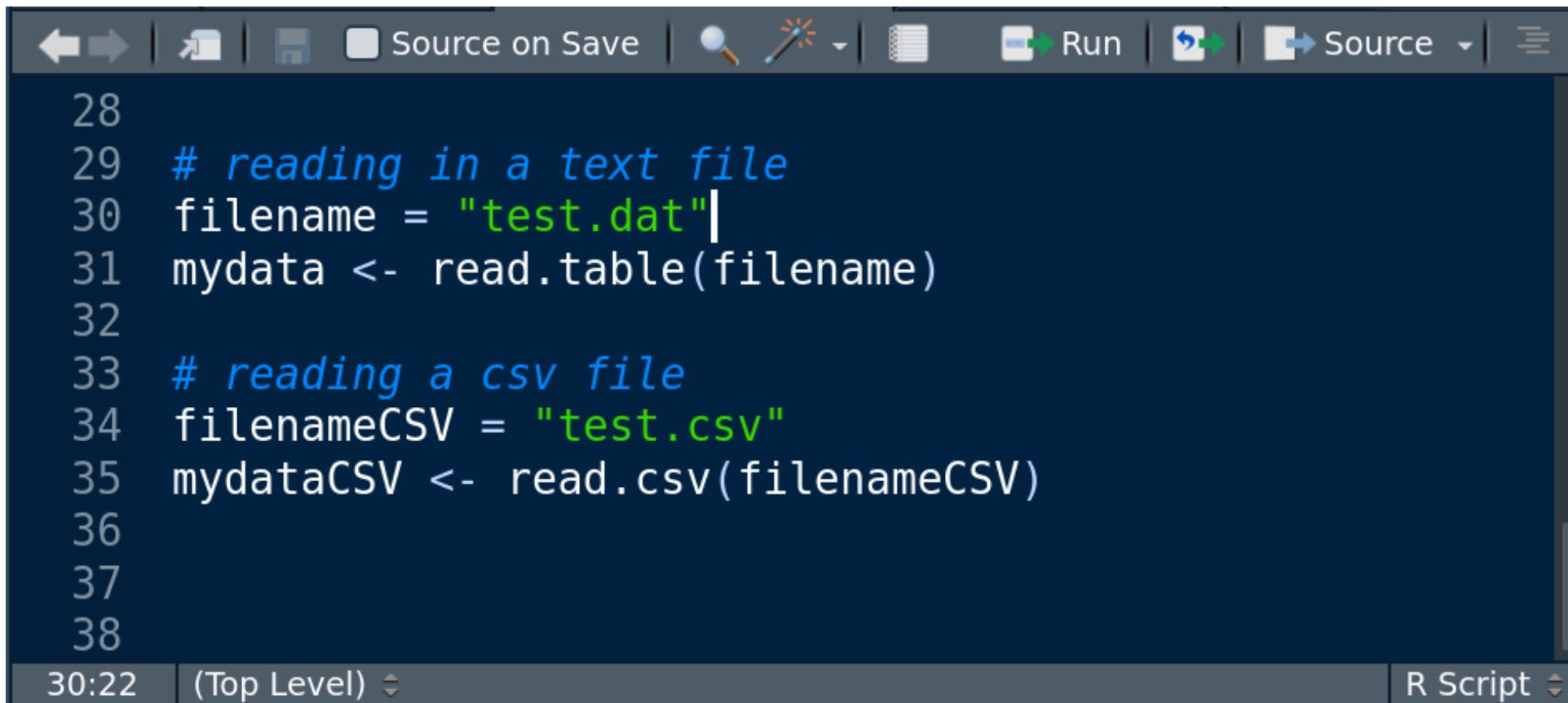
The status bar at the bottom shows "30:22 (Top Level) R Script".

COOL CATCH

R has a class of objects called *Factors*. Sometimes you don't want these, so you'll want to set the argument `StringsAsFactors = FALSE`



Input and Output into R



The screenshot shows the RStudio interface with the following details:

- Toolbar:** Includes icons for back, forward, file, source on save, search, and run.
- Code Editor:** Displays R code with line numbers 28 through 38. Lines 29 and 33 are comments. Lines 30 and 34 define filenames. Lines 31 and 35 read data from these files into objects named mydata and mydataCSV respectively.
- Status Bar:** Shows "30:22" and "(Top Level)" on the left, and "R Script" on the right.

```
28
29 # reading in a text file
30 filename = "test.dat"
31 mydata <- read.table(filename)
32
33 # reading a csv file
34 filenameCSV = "test.csv"
35 mydataCSV <- read.csv(filenameCSV)
36
37
38
```

- What class of objects are these?

Input and Output into R

The screenshot shows the RStudio interface. On the left, a code editor window displays R code for reading files. On the right, a terminal window shows the execution of this code and its output.

Code in the editor:

```
28  
29 # reading in a text file  
30 filename = "test.dat"  
31 mydata <- read.table(filename)  
32  
33 # reading a csv file  
34 filenameCSV = "test.csv"  
35 mydataCSV <- read.csv(filenameCSV)  
36  
37  
38
```

Time and level indicator: 30:22 (Top Level) ↴

Console output:

```
Console Terminal × Jobs ×  
~/Documents/Work/Service/DADD/  
>  
>  
> class(mydata)  
[1] "data.frame"  
> class(mydataCSV)  
[1] "data.frame"  
>
```

- What class of objects are these?

Input and Output into R

```
28  
29 # reading in a text file  
30 filename = "test.dat"  
31 mydata <- read.table(filename)  
32  
33 # reading a csv file  
34 filenameCSV = "test.csv"  
35 mydataCSV <- read.csv(filenameCSV)  
36  
37  
38 30:22 (Top Level) ▾
```



Demo Time!
Look at the data

```
Console Terminal × Jobs ×  
~/Documents/Work/Service/DADD/  
>  
>  
> class(mydata)  
[1] "data.frame"  
> class(mydataCSV)  
[1] "data.frame"  
> |
```

- What class of objects are these?

Input and Output into R

- You can write to different kinds of files

A screenshot of the RStudio interface. The code editor shows a portion of an R script with several functions listed in a dropdown menu: write.csv, write.csv2, write.dcf, write.ftable, write.socket, write.table, and write. A tooltip for 'write.table' is displayed, providing its function signature and a brief description: 'write.table prints its required argument x (after converting it to a data frame if it is not one nor a matrix) to a file or connection.' The RStudio toolbar at the bottom includes tabs for Environment, History, Connections, and Presentation.

- And save R objects to reload later

A screenshot of the RStudio interface. The code editor shows a portion of an R script with several functions listed in a dropdown menu: save, rle, plot, d, ls, and saveRDS. A tooltip for 'object' is displayed, defining it as 'R object to serialize.' The RStudio toolbar at the bottom includes tabs for Environment, History, Connections, and Presentation.

HOT TIP

Want to look at the help file for a particular function? Search in the command line directly with, e.g.,
>?write.table
Looking for a function?
>??write



Plotting and visuals in RStudio

- "base" R has generic plotting functions, and they are customizable and *object-oriented*

```
# default, simplest plot of x and y data  
plot(mydata$V1, mydata$V2)
```

Plotting and visuals in RStudio

- "base" R has generic plotting functions, and they are customizable and *object-oriented*

```
# default, simplest plot of x and y data
plot(mydata$V1, mydata$V2)
```

```
# make it a little prettier with some options
par(mar=c(5,5,3,3)) # bottom left top right margins
plot(mydata$V1, mydata$V2, xlab="x data", ylab="f(x)
data", cex.lab=1.7, type="l")
grid()
box()
```

Plotting and visuals in RStudio

- "base" R has generic plotting functions, and they are customizable and *object-oriented*

```
# default, simplest plot of x and y data
plot(mydata$V1, mydata$V2)
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```
# make it a little prettier with some options
par(mar=c(5,5,3,3)) # bottom left top right margins
plot(mydata$V1, mydata$V2, xlab="x data", ylab="f(x)
data", cex.lab=1.7, type="l")
grid()
box()
```

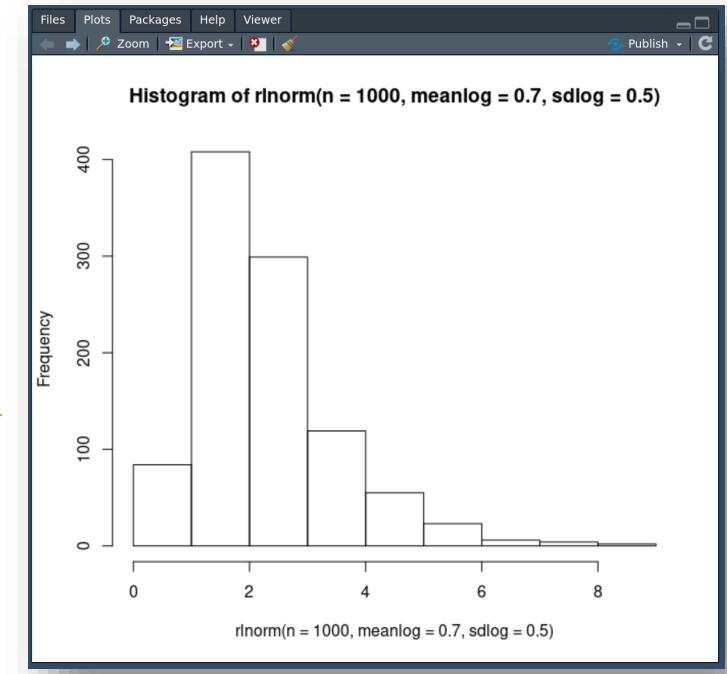


Demo Time!
Object-oriented programming

Plotting and visuals in RStudio

- basic histogram

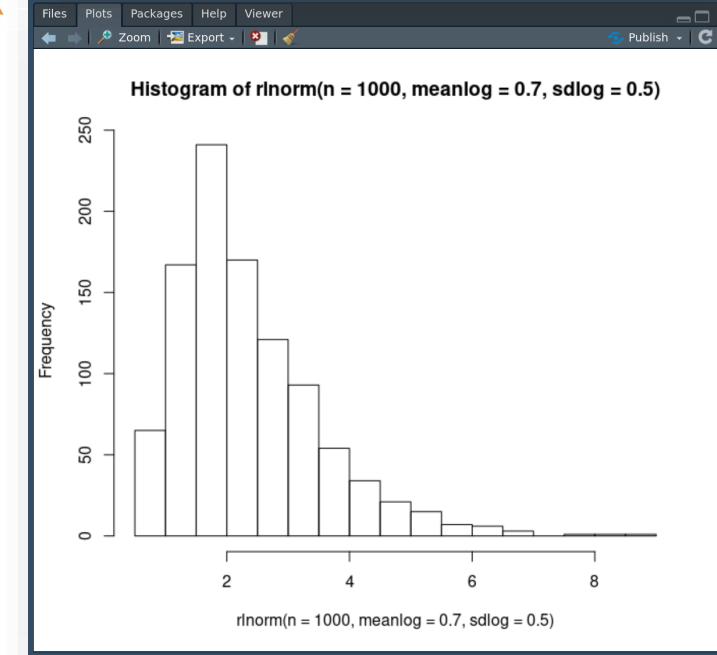
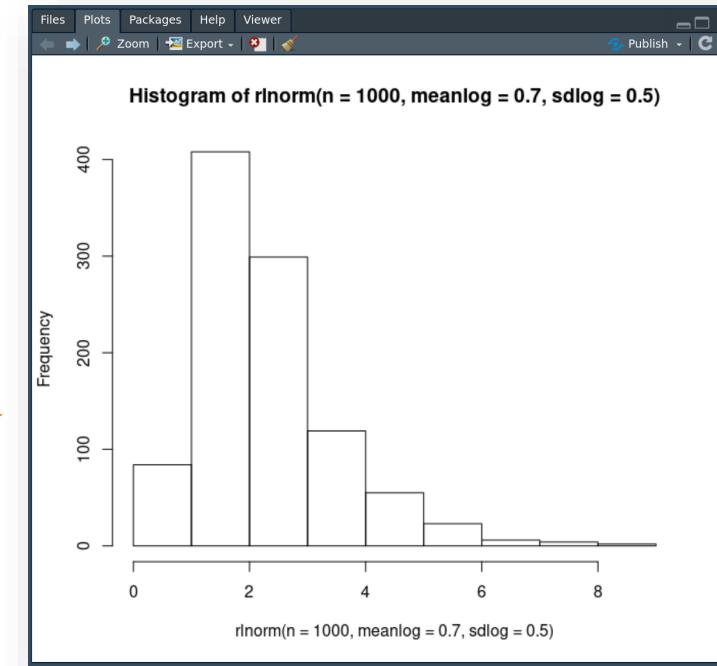
```
46 # default simple histogram
47 hist(rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5))
48 |
49 # simple histogram where we set the bin size
50 hist(rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5), breaks = 15)
51
```



Plotting and visuals in RStudio

- basic histogram

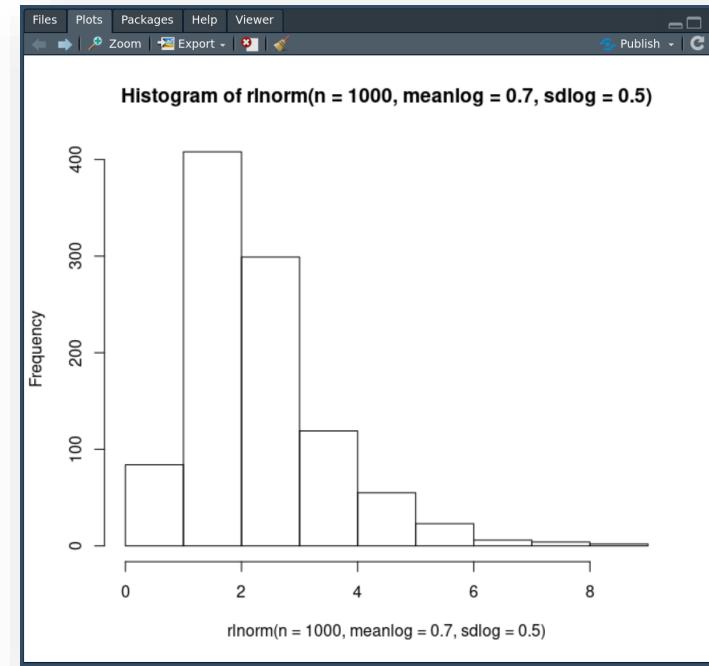
```
46 # default simple histogram  
47 hist(rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5))  
48 |  
49 # simple histogram where we set the bin size  
50 hist(rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5), breaks = 15)  
51
```



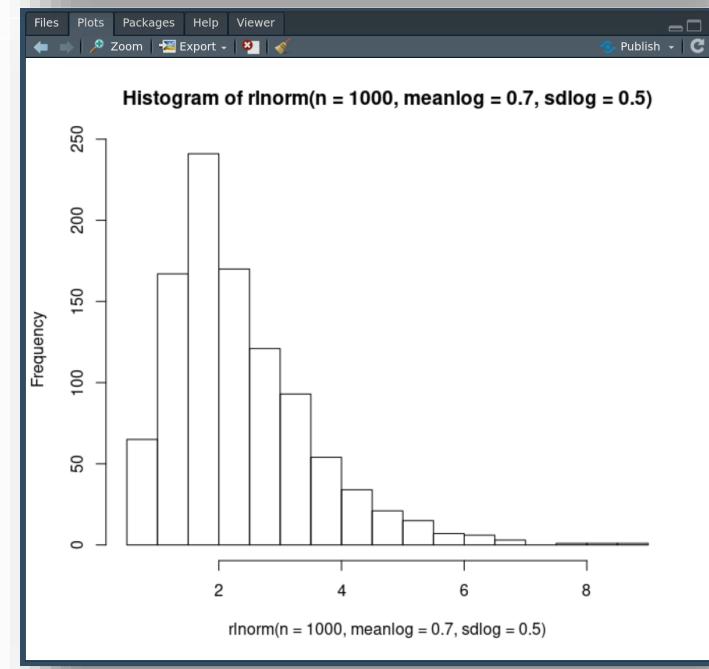
Plotting and visuals in RStudio

- basic histogram

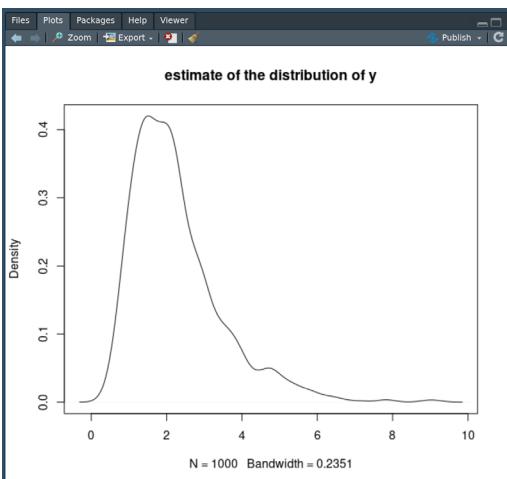
```
46 # default simple histogram  
47 hist(rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5))  
48 |  
49 # simple histogram where we set the bin size  
50 hist(rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5), breaks = 15)  
51
```



```
52 # save the random draws from the lognormal  
53 y <- rlnorm(n = 1e3, meanlog = 0.7, sdlog = 0.5)  
54 # plot the kernel density estimate of the random y values  
55 plot( density(y), main="estimate of the distribution of y" )  
56
```



- *Object-oriented programming!*



ggplot2



- The *ggplot2* package is extremely popular for data visualization
 - (you've probably seen plots made in R with ggplot2 without knowing it!)

ggplot2



- The *ggplot2* package is extremely popular for data visualization
 - (you've probably seen plots made in R with ggplot2 without knowing it!)



ggplot2



Demo Time!
Super simple ggplot2 plot



- The *ggplot2* package is extremely popular for data visualization
 - (you've probably seen plots made in R with ggplot2 without knowing it!)



RStudio Cheatsheets

<https://rstudio.com/resources/cheatsheets/>

HOT TIP

Check out the ones for Data Visualisation (ggplot2), Reticulate, Shiny Apps, and more



RStudio Cheatsheets

The cheatsheets below make it easy to use some of our favorite packages. From time to time, we will add new cheatsheets. If you'd like us to drop you an email when we do, click the button below.

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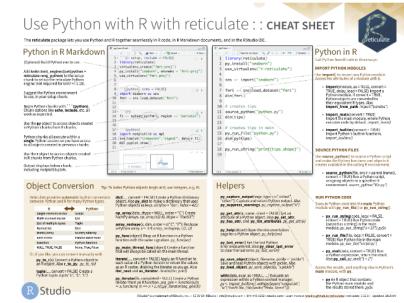
[TRANSLATIONS](#)

[HOW TO CONTRIBUTE](#)

Python with R and Reticulate Cheatsheet

The [reticulate](#) package provides a comprehensive set of tools for interoperability between Python and R. With reticulate, you can call Python from R in a variety of ways including importing Python modules into R scripts, writing R Markdown Python chunks, sourcing Python scripts, and using Python interactively within the RStudio IDE. This cheatsheet will remind you how.

Updated March 19.



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Mini-exercise 2

- Generate 100 random numbers from a Gaussian distribution
- Generate 100000 random numbers from a Gaussian distribution and show that they are much better approximated by a Gaussian distribution (i.e. plot a Gaussian curve)

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{x-\mu}{\sigma}\right)^2}$$

HOT TIP

Here is where you'll really see the difference between R and Python



Exercise

- *In Python*
 - Read in the data from the data file A provided
 - Change the precision of the data file (reduce the floating point precision to 1 decimal place, or make them integers)
 - Apply a 50% Gaussian scatter to the data points
 - Make a plot of your data and save it to file B
 - Save the data to a text file
- *In R*
 - Read in that text file B that you saved in the step above
 - Compute the summary statistics of the data
 - Plot the data
 - Plot the five number summary statistics (hint: look up **?boxplot**)
 - Read in the original data file A used in the step above
 - Compare the summary statistics of the A data with the B data
 - Make a plot and save it to file
 - Save original data A to file with increased precision

HOT TIP

For your stretch goal – make doc strings for this whole package!

