



Introduction to Python

Python Crash Course
DATA 601

Before We Start

Please follow the directions in the following slides and make sure that you have a healthy python environment to run your own codes while learning!

Some of the early lectures will have some advanced subjects. If you don't understand, please take a note but do not panic. In the following lectures, we will cover those advanced subjects in detail.

Download & Install

Recommended Approach:

Download latest version of Anaconda Distribution and install it

<https://www.anaconda.com/distribution/>

Once the installation complete, run Anaconda Navigator



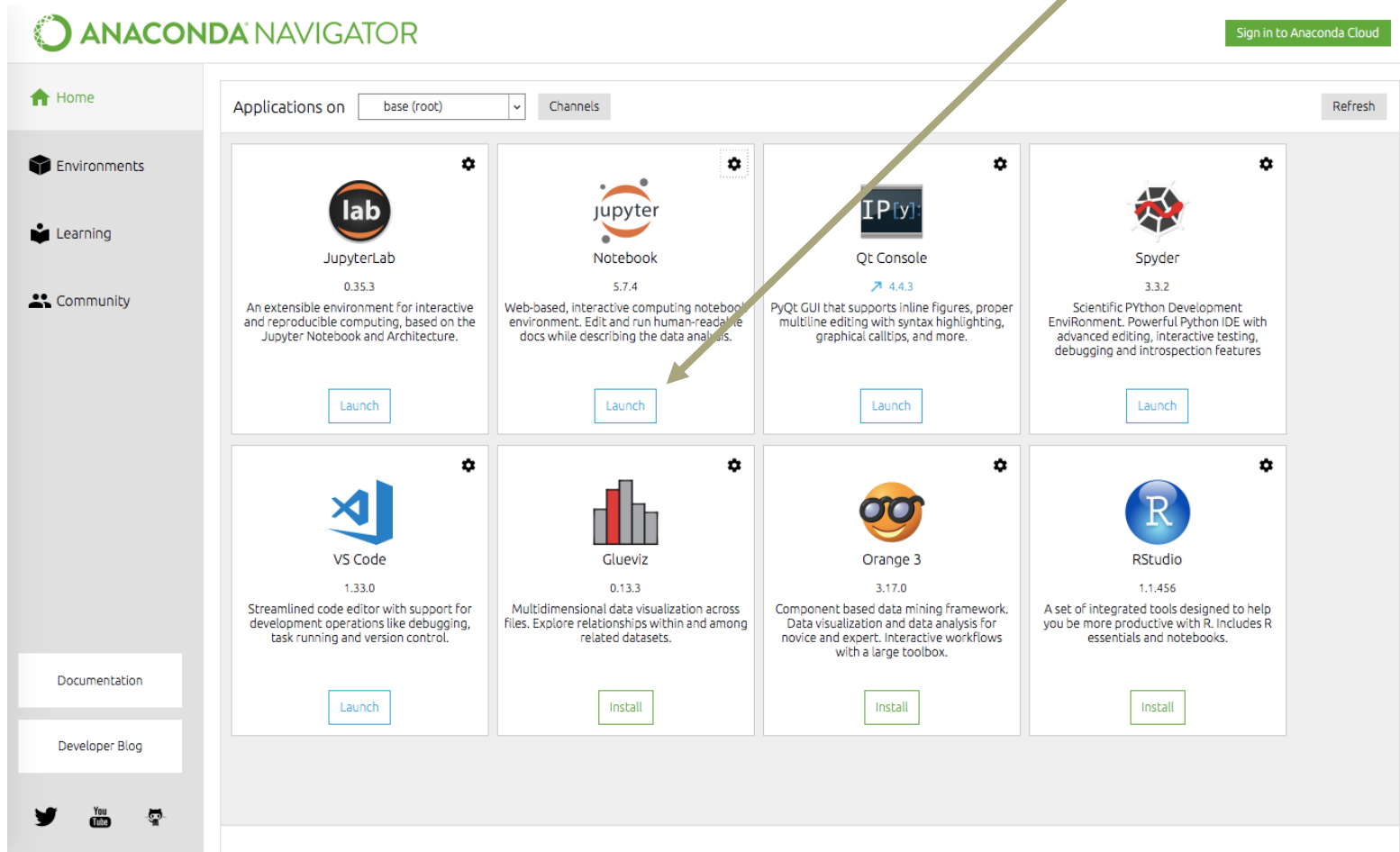
Alternatively:

Download Python 3 (or newer version) from

<https://www.python.org/downloads/>

and install it.

If you see this, lunch “Jupyter Notebook” simply by clicking here



ANACONDA NAVIGATOR [Sign in to Anaconda Cloud](#)

Applications on base (root) Channels Refresh

Application	Version	Description	Action
lab JupyterLab	0.35.3	An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.	Launch
jupyter Notebook	5.7.4	Web-based, interactive computing notebook environment. Edit and run human-readable docs while describing the data analysis.	Launch
IP[y] Qt Console	4.4.3	PyQt GUI that supports inline figures, proper multiline editing with syntax highlighting, graphical calltips, and more.	Launch
Spyder	3.3.2	Scientific Python Development Environment. Powerful Python IDE with advanced editing, interactive testing, debugging and introspection features	Launch
VS Code	1.33.0	Streamlined code editor with support for development operations like debugging, task running and version control.	Launch
Glueviz	0.13.3	Multidimensional data visualization across files. Explore relationships within and among related datasets.	Install
Orange 3	3.17.0	Component based data mining framework. Data visualization and data analysis for novice and expert. Interactive workflows with a large toolbox.	Install
R RStudio	1.1.456	A set of integrated tools designed to help you be more productive with R. Includes R essentials and notebooks.	Install

Documentation
Developer Blog

[Twitter](#) [YouTube](#) [GitHub](#)

Jupyter Notebook

If your internet browser opens a new tab like this, you are ready to go



If somehow it didn't work, backup plan is using Google COLAB

➔ Next Slide

Google Colab

If you don't have an UMBC email or another gmail account, first you need to create a Google Account for yourself at

<https://accounts.google.com>

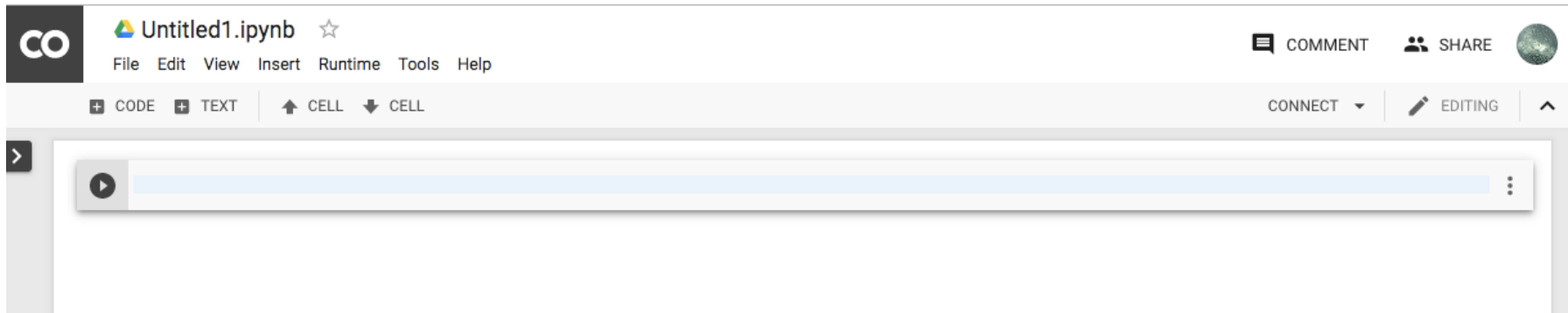
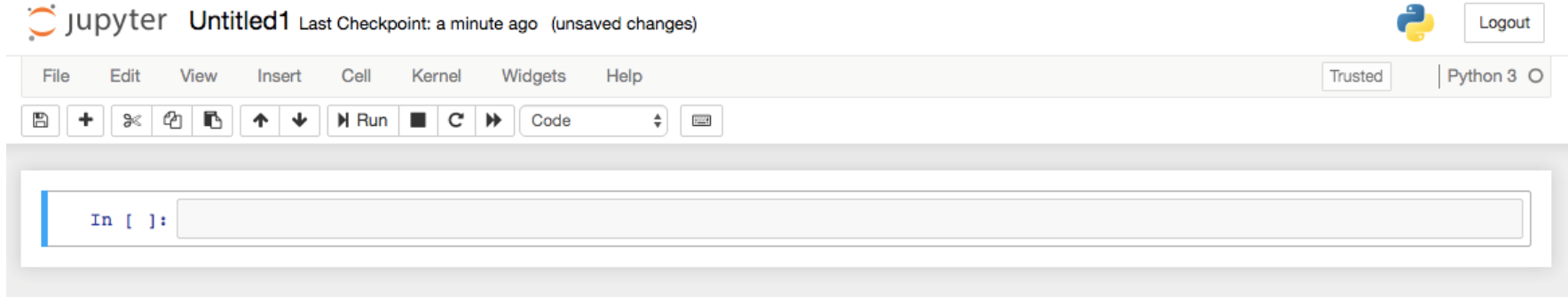
Sign into your google account. Then go to

<https://colab.research.google.com/>

What you see is free Jupyter notebook environment that requires no setup and runs entirely in the cloud.

1. Click File
2. Choose "Python 3 Notebook"

If you All Have either of these, We are ready to start



Python is an object-oriented, high-level programming language with integrated dynamic semantics primarily for web and app development.

Python is relatively simple, so it's easy to learn since it requires a unique syntax that focuses on readability.

Python supports the use of modules and packages, so that programs can be designed in a modular style and code can be reused across a variety of projects.

What is Python?



Why Python?

Open Source/Free: No need to worry about licences

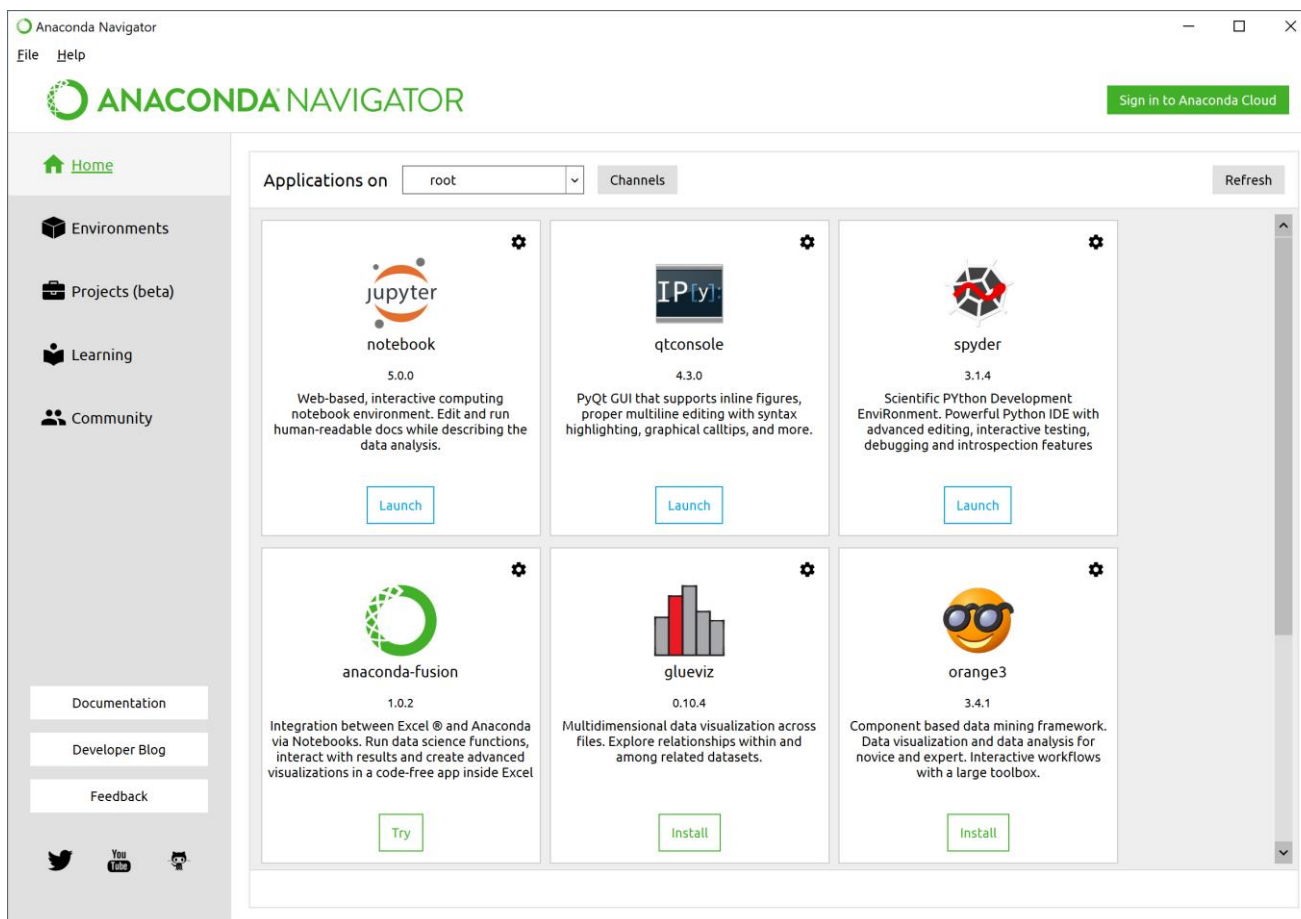
Cross-platform: Can be used with Windows/Macs OS/Linux – even Android and iOS!

Full-featured Packages: If there's something you want to do, there's probably a package out there to help you

Code Portability: With most code, it can run unaltered on a plethora of computers so long as all the required modules are supplied

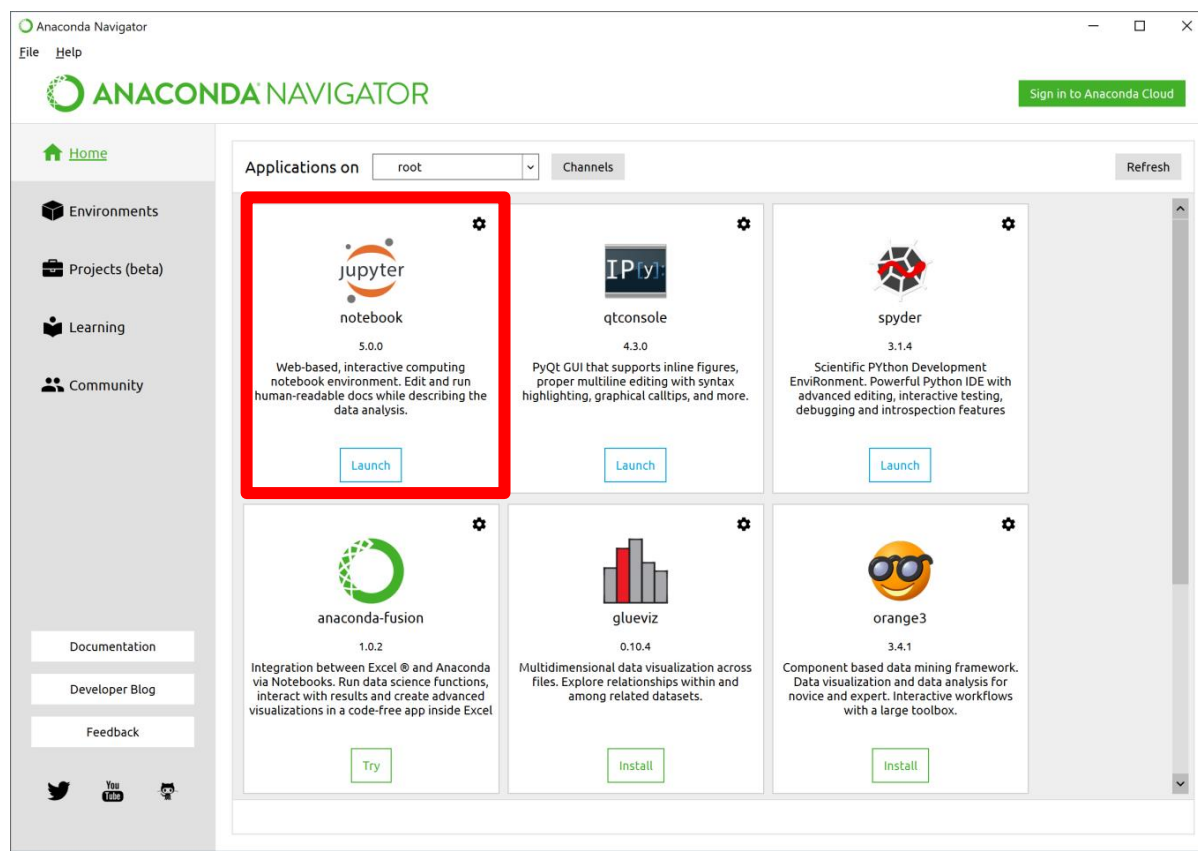
Large and Growing Community: People from all fields from Data Science to Physics are coding in Python, creating a diverse and rich community of experts all over.

Anaconda: What We'll be Using



Anaconda is a distribution that uses the conda tool to manage packages.

JUPYTER Notebook



PRO TIP:

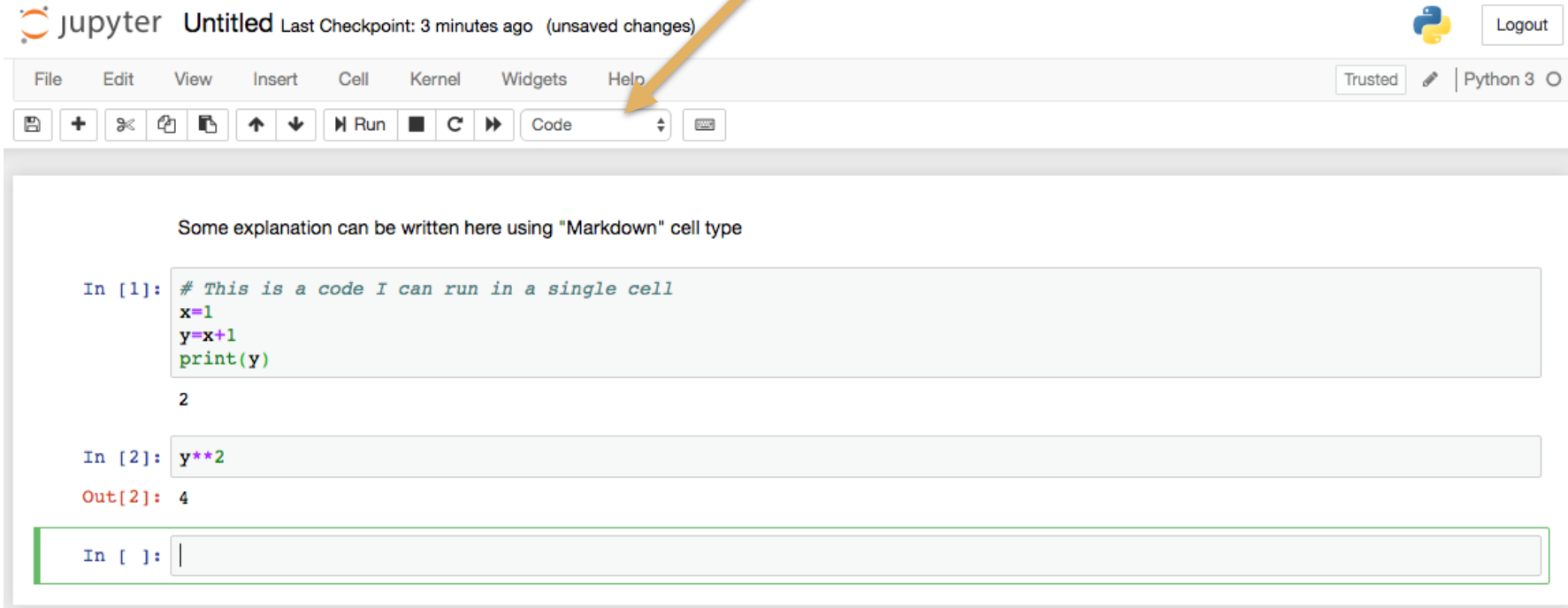
From command line:
\$ jupyter notebook

Can launch from Anaconda: runs a python session in the background

JUPYTER Notebook

PRO TIP:

Change "Code" to "Markdown" for explanations



jupyter Untitled Last Checkpoint: 3 minutes ago (unsaved changes)

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Code

Some explanation can be written here using "Markdown" cell type

```
In [1]: # This is a code I can run in a single cell
x=1
y=x+1
print(y)
```

2

```
In [2]: y**2
```

Out[2]: 4

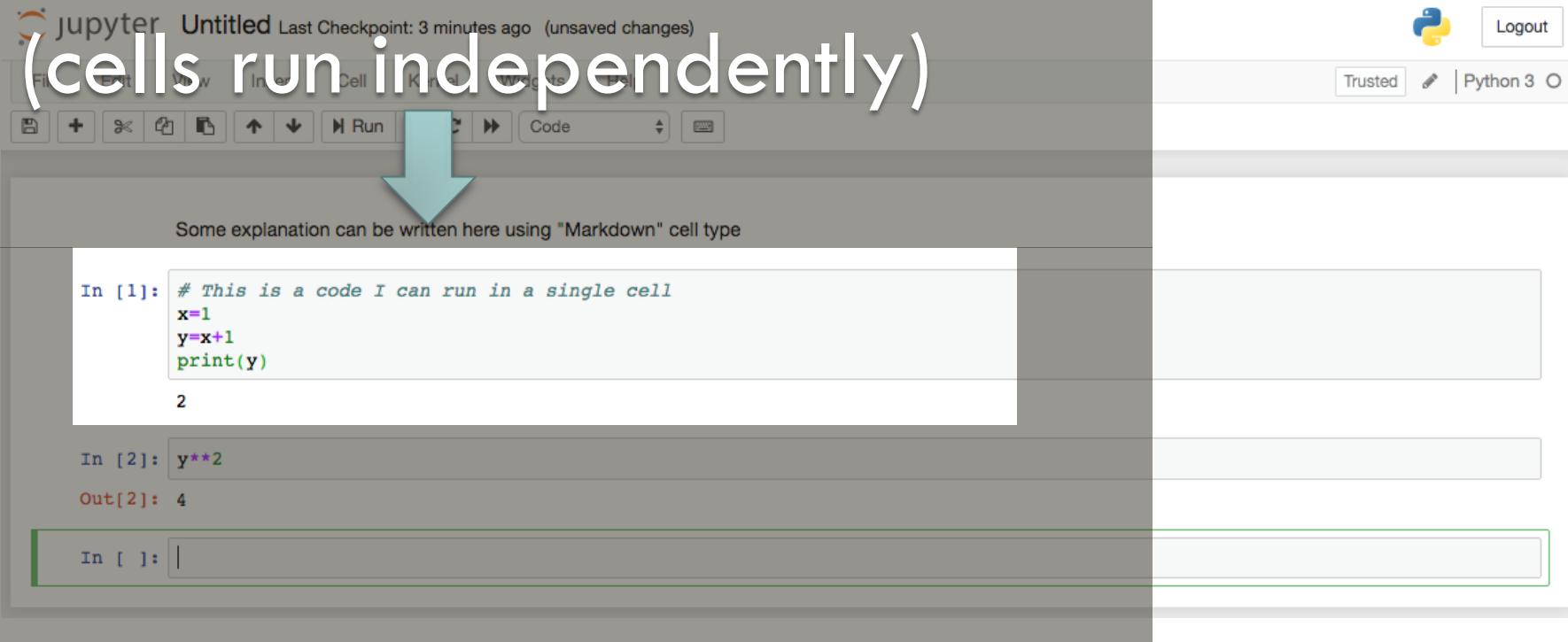
```
In [ ]:
```

Runs a “notebook” in a web browser. Keeps code and notes together.

JUPYTER Notebook

Code

(cells run independently)



The screenshot displays a Jupyter Notebook interface. At the top, the title bar shows 'jupyter Untitled' with a status message 'Last Checkpoint: 3 minutes ago (unsaved changes)'. On the right, there is a 'Logout' button and a 'Trusted' status indicator. Below the title bar is a toolbar with icons for file operations, navigation, and execution. The main area contains three code cells. The first cell is a Markdown cell with the text 'Some explanation can be written here using "Markdown" cell type'. The second cell is a code cell with the following Python code:

```
In [1]: # This is a code I can run in a single cell
x=1
y=x+1
print(y)
```

 The output of this cell is the number '2'. The third cell is a code cell with the following Python code:

```
In [2]: y**2
```

 The output of this cell is '4'. A large blue arrow points from the text '(cells run independently)' to the first code cell.

jupyter Untitled Last Checkpoint: 3 minutes ago (unsaved changes)

Trusted Python 3

Logout

Some explanation can be written here using "Markdown" cell type

```
In [1]: # This is a code I can run in a single cell
x=1
y=x+1
print(y)
```

2

```
In [2]: y**2
```

Out[2]: 4

```
In [ ]: 
```

File

- New Notebook
- Open...
- Make a Copy...
- Save as...
- Rename...
- Save and Checkpoint
- Revert to Checkpoint
- Print Preview
- Download as
- Trusted Notebook
- Close and Halt

Edit

- Cut Cells
- Copy Cells
- Paste Cells Above
- Paste Cells Below
- Paste Cells & Replace
- Delete Cells
- Undo Delete Cells
- Split Cell
- Merge Cell Above
- Merge Cell Below
- Move Cell Up
- Move Cell Down
- Edit Notebook Metadata
- Find and Replace
- Cut Cell Attachments
- Copy Cell Attachments
- Paste Cell Attachments
- Insert Image

Insert

- Insert Cell Above
- Insert Cell Below

Cell

- Run Cells
- Run Cells and Select Below
- Run Cells and Insert Below
- Run All
- Run All Above
- Run All Below
- Cell Type
- Current Outputs
- All Output

Kernel

- Interrupt
- Restart
- Restart & Clear Output
- Restart & Run All
- Reconnect
- Shutdown
- Change kernel

Modules: The Power of Python

The base language of Python is actually quite limited.

Most of its power comes from **Modules** (or sometimes referred to as **Packages**)

Modules must be **imported** before they can be used:

```
In [1]: import math  
In [2]: import math, statistics
```

Importing single or multiple modules on a single line

Once imported, you can access functions or variables:

```
In [3]: math.cos(math.pi)
```

Modules: The Power of Python

Sometimes typing the module name all the time can be annoying in which case:

Creating a shorter name or just getting the function you want

```
In [1]: import numpy as np  
In [2]: from numpy import zeros
```

Once imported, you can access functions or variables:

```
In [3]: np.ones(5)  
Out[3]: array([1., 1., 1., 1., 1.])  
In [4]: zeros(5)  
Out[4]: array([0., 0., 0., 0., 0.])
```


Modules: The Power of Python

Observe the difference

```
[1]: import math
```

```
[2]: math.cos(math.pi)
```

```
[2]: -1.0
```

vs.

```
[1]: from math import cos, pi
```

```
[2]: cos(pi)
```

```
[2]: -1.0
```

Modules: The Power of Python

PRO TIP:

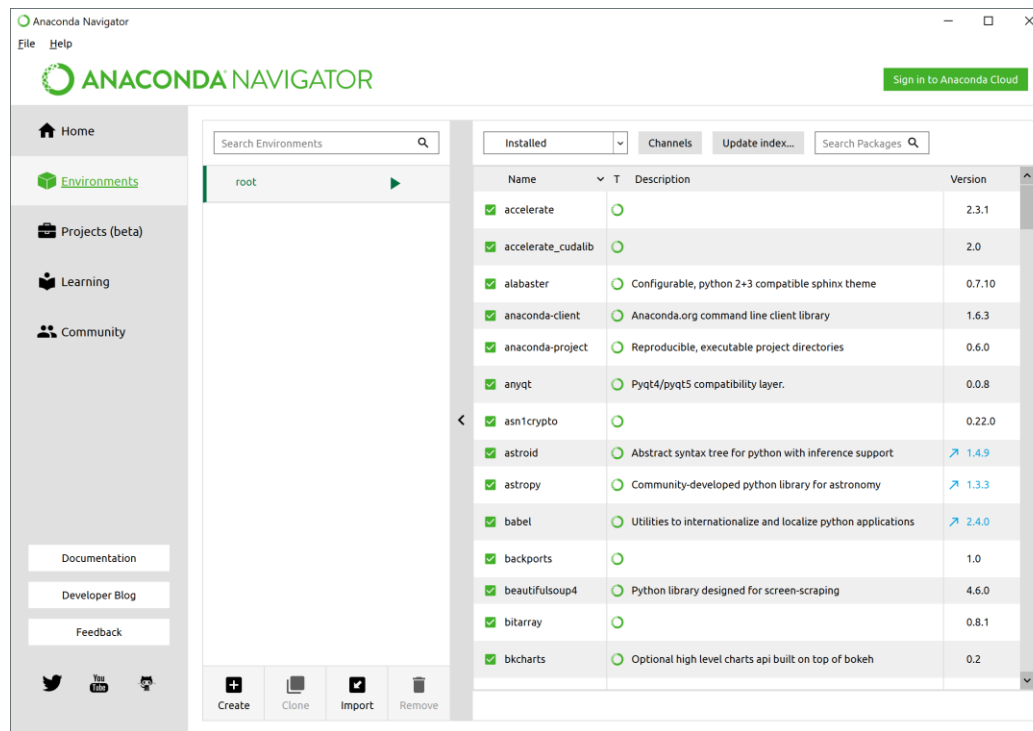
Some places will show examples that involve importing all functions in a module by:

```
from module1 import *
```

While this may seem handy, it is dangerous. **DON'T DO THIS!**
It messes with your namespace!

Installing New Modules

Anaconda provides the majority of modules you'll want and/or need automatically. But there are modules that you'll likely want to get. Anaconda makes this easy using the **Environments Tab**



Installing New Modules

Python also makes installing packages easy in general using **conda** on the command line:

```
$ conda install numpy
```

This downloads and installs any package available on the (centralized) Anaconda repository.

To find a package:

```
$ conda search numpy
```

We will talk about modules in great detail later.
For the moment, just know that Python's power comes from
modules and they are very easy to install

Basics of a Script: Comments

The most important part of any script

```
In [1]: # This is a comment  
In [2]: # This is also a comment
```

For longer comments (in a script for instance):

```
'''  
This text is in a comment  
So is this text  
'''  
This text is outside a comment
```

Basics of a Script: Indentation

In the next slide, there is a “for loop” and an “if statement”

We will learn how those loops and statements work later.

The purpose of the next slide is showing you that indentation is important for Python

Basics of a Script: Indentation

Python uses indents to indicate blocks of code – no brackets!

```
# Indentation example
x = 1
y = 2
for i in (1, 2, 3):
    x = x + i
    y = y + i
    if x > y:
        print('Something is wrong!')
    print(x, y)
print('All done.')
```

Let your text editor deal with indenting for you. And when you need to do it yourself, *use spaces not tabs*. Python is picky about it!

Basics of a Script: Variables

What are variables?

Variables are the combination of an identifying label and a value, often a literal like 2 or "hello world". The label/identifier is attached to the value thus:

```
In [1]: a = 10
```

This is called variable **assignment**.

Once assigned, when you use the label, you get the value:

```
In [2]: print(a)  
Out[2]: 10
```

Note that this is not the same as:

```
In [3]: print("a")  
Out[2]: a
```


Basics of a Script: Variables (Cont...)

There is no need to declare any variable type before setting it

```
In [1]: x = 1          # No need to declare x is an integer
In [2]: y, z = 100, 200
```

Anything can be a variable in python: numbers, strings, functions, modules, *et cetera*. You can check out what type the variable is by:

```
In [3]: type(x)
Out[3]: int
```

They are called variables because you can change the value:

```
In [4]: x=1
In [5]: print(x)
Out[5]: 1
In [6]: x=2.1
In [7]: print(x)
Out[7]: 2.1
```

Basics of a Script: Variables (Cont...)

The label is just pointing to the value, which is stored somewhere in the computer **memory**.

```
In [1]: a=10
In [2]: b=a
In [3]: b
Out[3]: 10
In [4]: b=20
In [5]: a
Out[5]: 10
In [6]: b
Out[6]: 20
```

Variable identifiers

Names can be any continuous word/s, but must **start with a letter or underscores**.

There is no relationship between a variable's value or use and its name. In the last simple examples, a and b were fine, but generally you should name variables so you can tell what they are used for:

```
radius = 10
```

is more meaningful than

```
a = 10
```

or

```
bob = 10
```

In general, the more meaningful your names, the easier it will be to understand the code, when you come back to it, and the less likely you are to use the wrong variable.

Name Style

Style conventions aren't syntax, but allow all coders to recognise what an element is.

There's a styleguide for Python at:

<https://www.python.org/dev/peps/pep-0008/>

But it goes out of its way to avoid talking about variable names.

The community preference seems to be for lowercase words to be joined with underscores; what is called (coincidentally) **snake_case**:

```
perimeter_of_a_square
```

Though where Python is working with C or other code, the more conventional **camelCase** is sometimes used:

```
perimeterOfASquare
```

Either way, start with a lowercase letter, as other things start uppercase.

More on variables

You may see variables described as containers for values, but this isn't true and isn't helpful. Think of them as labels and values.

As we'll see later on, it is quite easy to get confused about what a variable is referring to, and thinking about them as a identifier/label and value helps.

Why we use variables?

Variables are generally used to hold the result of calculations and user inputs. These are things we can't predict before the code is run.

Some things we can predict the value of, for example, the 4 in:

```
perimeter = 4 * length_of_side # perimeter of a square
```

Such literals are **hardwired** in.

Even such literals are often better put in a variable at the top of the file, as changing the variable instantly allows us to change the value throughout:

```
number_of_sides = 4  
perimeter = number_of_sides * length_of_side
```

This now works for any regular shape if we change `number_of_sides`.

Values

What kinds of things can we attached to variable labels?

Everything!

Literals like 1, 1.1, "a", "hello world".

But also whole chunks of code.

All the code and values in the computer is held in the form of binary data. We don't usually see this, but it is. It has to be: computers are just very complicated sets of on and off switches.

If values are just spaces in memory with something in them, and all code and values is binary, if we can attach a label to a value in memory, we can attach it to code in memory.

This is the basis of object oriented computing.

Objects

- Objects are chunks of code that are wrapped up in a particular way.
- One thing this format enables is the attaching of labels to them to create variables.
- Objects can have their own functions and variables, so you can have variables inside other variables.
- Objects generally do some particular job.
- We'll talk about them more later.

Values

In Python (but not all other languages), functions themselves are objects that can be given labels:

```
>>> a = print  
>>> a("hello world")  
hello world
```

This makes it incredibly powerful: for example, we can pass one function into another (the core of functional programming).

```
>>> dir(a)
```

Values

How does the computer know what a variable is?

For Python, it works it out. This takes it a little time, but means it is much more flexible.

This is why Python is more time and energy consuming compared to C, Fortran, etc.

Basics of a Script: Primitive Variables

There are only a few built-in variables in python, with standard operations:

Strings (str)

Integers (int)

Floats (float)

Any form of text. These can be enclosed in single (') or double (") quotes.

```
In [1]: var1 = 'This is a String'  
In [2]: var2 = "This is also a String"
```

When added, they make a longer string:

```
In [3]: var1 + var2  
Out[3]: 'This is a StringThis is also a String'
```

Basics of a Script: Primitive Variables

There are only a few built-in variables in python, with standard operations:

Strings (str)

Integers (int)

Floats (float)

They also accept **escape characters** (i.e., `\n`, `\t`, `\a`)

```
In [1]: var1 = 'This is a String \n'  
In [2]: var2 = 'This is also a String'
```

When added, they make a longer string:

```
In [3]: print(var1+var2)  
Out[3]: This is a String  
        This is also a String
```

Basics of a Script: Primitive Variables

There are only a few built-in variables in python, with standard operations:

Strings (str)

Integers (int)

Floats (float)

Any integer (... , -1, 0, 1, ...). Mathematical operations are as you expect

```
In [1]: var1, var2 = 1, 2
```

They are subject to floating point math:

```
In [2]: var1 / var2    # Regular division
Out[2]: 0.5
In [3]: var1 // var2   # Integer division - drop
fraction
Out[3]: 0
```

Basics of a Script: Primitive Variables

There are only a few built-in variables in python, with standard operations:

Strings (str)

Integers (int)

Floats (float)

Any integer (... , -1, 0, 1, ...). Mathematical operations are as you expect

```
In [1]: var1, var2 = 5, 2
```

They are subject to floating point math:

```
In [2]: var1 / var2    # Regular division
Out[2]: 2.5
In [3]: var1 // var2   # Integer division - drop
fraction
Out[3]: 2
```

Basics of a Script: Primitive Variables

There are only a few built in variables in python:

Strings (str) Integers (int) Floats (float)

Any real number (1.0, 2.5, 1e25). Mathematical operations are as you expect

```
In [1]: var1, var2 = 1.0, 2e2
In [2]: var1, var2
Out[2]: (1.0, 200.0)
In [3]: 1/2.0 # int and float results in float
Out[3]: 0.5
```

Basics of a Script: Primitive Variables

There are only a few built in variables in python:

Strings (str)

Integers (int)

Floats (float)

Any real number (1.0, 2.5, 1e25). Mathematical operations are as you expect

```
In [1]: var1, var2 = 1.0, 2e2
```

```
In [2]: var1, var2
```

```
Out[2]: (1.0, 200.0)
```

```
In [3]: 1/2.0 # int and float results in float
```

```
Out[3]: 0.5
```


Basics of a Script: Primitive Variables

There are only a few built in variables in python:

Strings (str)

Integers (int)

Floats (float)

Any real number (1.0, 2.5, 1e25). Mathematical operations are as you expect

```
In [1]: var1, var2 = 1.0, 2e2
In [2]: var1, var2
Out[2]: (1.0, 200.0)
In [3]: 1/2.0 # int and float
Out[3]: 0.5
```

NOTE:

There is also a Boolean data type (bool). It can only have the values True or False.

Python and Complex Numbers

Python can handle complex numbers as well

```
In [1]: w = 3+4j  
In [2]: print(type(w))  
Out[2]: <class 'complex'>
```

Python and Scientific Numbers

Float can also be scientific numbers with an "e" to indicate the power of 10.

```
In [1]: x= 1.1e3  
In [2]: print(x)  
Out[2]: 1100.0
```

CASTING

There may be times when you want to specify a type on to a variable.

This can be done with casting

`int()` constructs an integer number from

- an integer literal,
- a float literal (by rounding down to the previous whole number),
- or a string literal (providing the string represents a whole number)

```
In [1]: x = int(1)
In [2]: y = int(2.8)
In [3]: z = int("3")
In [4]: print(x, y, z)
Out[4]: 1 2 3
```

CASTING (Cont...)

`float()` constructs a float number from

- an integer literal,
- a float literal or
- a string literal (providing the string represents a float or an integer)

```
In [1]: x = float(1)
In [2]: y = float(2.8)
In [3]: z = float("3")
In [4]: w = float("4.2")
In [5]: print(x,y,z,w)
Out[5]: 1.0 2.8 3.0 4.2
```

CASTING (Cont...)

`str()` constructs a string from a wide variety of data types, including strings, integer literals and float literals

```
In [1]: x = str("s1")
In [2]: y = str(2)
In [3]: z = str(3.0)
In [4]: w = str('Python Rocks')
In [5]: print(x,y,z,w)
Out[5]: s1 2 3.0 Python Rocks
```

More on Strings

Note that Python stores strings as arrays of bytes representing unicode characters. For example

`A_String = 'AbC DeF'`

`len('A_String')` returns 7

`A_String[0]` returns A

`A_String[1]` returns b

`A_String[-1]` returns F

`A_String[3]` returns an empty space

Some Very Useful String Methods

`strip()`, removes any whitespace from the beginning or the end

```
In [1]: Name3 = " Albert Einstein "  
In [2]: print(Name3.strip())  
Out[2]: Albert Einstein
```

`lower()` method returns the string in lower case

```
In [3]: Name3 = "Albert Einstein"  
In [4]: print(Name3.lower())  
Out[4]: albert einstein
```

`upper()` method returns the string in upper case:

```
In [5]: print(Name3.upper())  
Out[5]: ALBERT EINSTEIN
```

Some Very Useful String Methods (Cont...)

`replace()` method replaces a string with another string:

```
In [1]: prices = "$100, $200, $87, $500"  
In [2]: print(prices.replace("$", "€"))  
Out[2]: €100, €200, €87, €500
```

```
In [3]: prices = "$100, $200, $87, $500"  
In [4]: print(prices.replace("$", ""))  
Out[4]: 100, 200, 87, 500
```


Some Very Useful String Methods (Cont...)

`split()` method splits the string into substrings if it finds instances of the separator

```
In [1]: prices = "$100, $200, $87, $500"  
In [2]: print(prices.split(","))  
Out[2]: ['$100', ' $200', ' $87', ' $500']
```

The output is a list of strings.
We'll talk about "lists" in the
next session

```
In [3]: A_sentence = "I will go shopping today"  
In [4]: print(A_sentence.split(" "))  
Out[4]: ['I', 'will', 'go', 'shopping', 'today']
```

Combining Numbers and Strings

If you try to combine string and number without proper transformation, Python will give you an error.

Here we convert an integer to a string

```
In [1]: temperature = 74
In [2]: z = "Baltimore"
In [3]: print(z, 'is', str(temperature), "degrees Fahrenheit today.")
Out[3]: Baltimore is 74 degrees Fahrenheit today
```

Arithmetic Operators

Input

```
x = 12.0  
y = 2.0  
  
addition = x+y  
subtraction = x-y  
multiplication = x*y  
exponentiation = x**y  
division = 12.4/y  
floor_division = 12.4//y  
modulus = 10%3  
modulus = 10%3.0
```

Output

```
14.0  
10.0  
24.0  
144.0  
6.2  
6.0  
1  
1.0
```

Augmented Assignment Operators

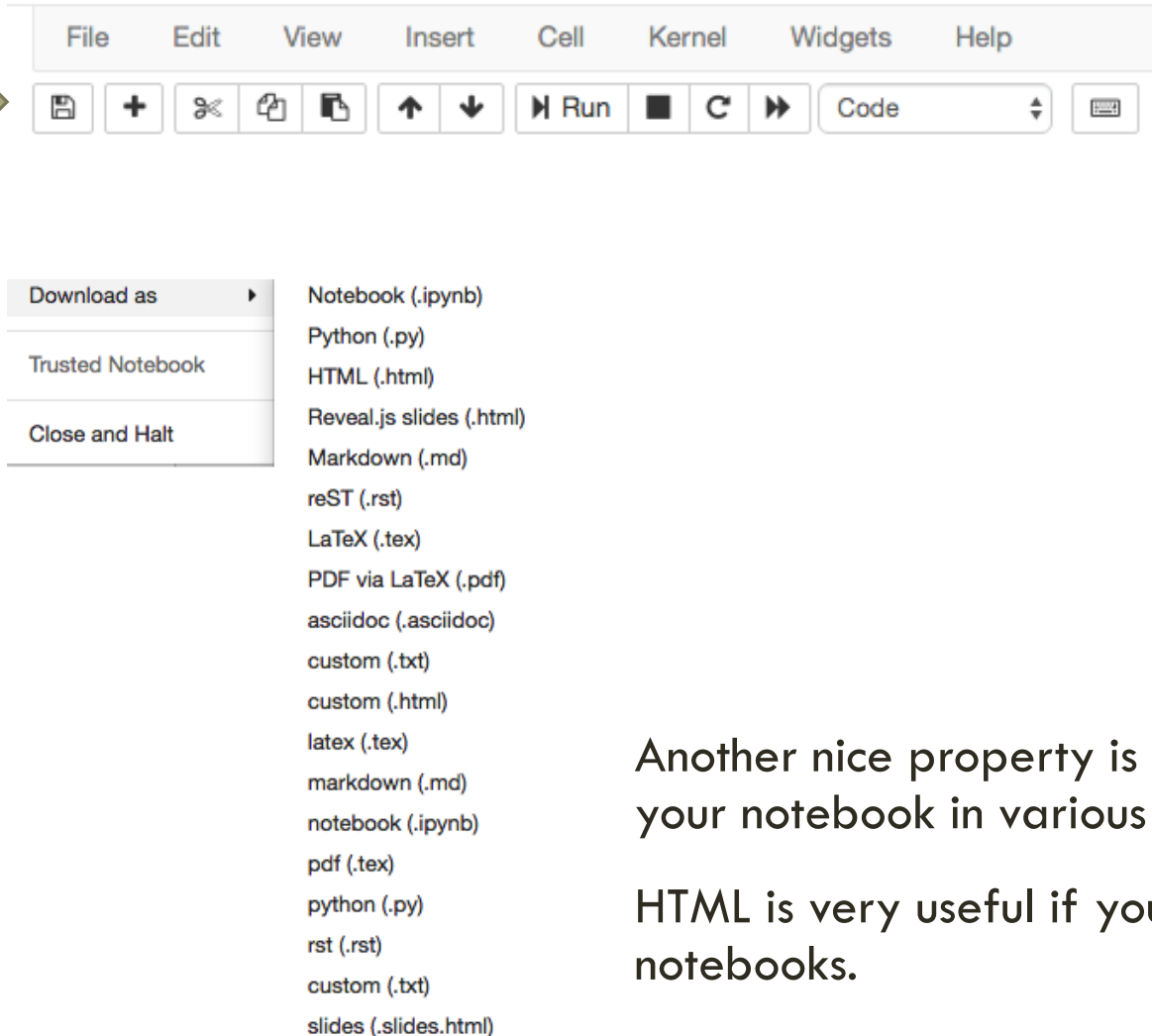
<code>x += 1</code>	# same as	<code>x = x + 1</code>
<code>x -= 1</code>	# same as	<code>x = x - 1</code>
<code>x *= 3</code>	# same as	<code>x = x * 3</code>
<code>x /= 3</code>	# same as	<code>x = x / 3</code>
<code>x //= 3</code>	# same as	<code>x = x // 3</code>
<code>x %= 3</code>	# same as	<code>x = x % 3</code>

Very useful operators for counting, indexing, etc.

Don't Forget to Save Your Notebooks



Even though Jupyter saves it every notebook you create, it is always good to give a meaningful name to your notebook, put some explanations at the very top, and save your file before you quit.



The image shows the Jupyter Notebook interface. At the top is a menu bar with the following items: File, Edit, View, Insert, Cell, Kernel, Widgets, and Help. Below the menu bar is a toolbar with icons for saving, creating new notebooks, opening recent notebooks, undo, redo, running cells, and other functions. A green arrow points to the 'File' menu. The 'File' menu is open, showing a 'Download as' dropdown menu. The 'Download as' menu lists various file formats for downloading the notebook, including Notebook (.ipynb), Python (.py), HTML (.html), Reveal.js slides (.html), Markdown (.md), reST (.rst), LaTeX (.tex), PDF via LaTeX (.pdf), asciidoc (.asciidoc), custom (.txt), custom (.html), latex (.tex), markdown (.md), notebook (.ipynb), pdf (.tex), python (.py), rst (.rst), custom (.txt), and slides (.slides.html).

Another nice property is that you can download your notebook in various different formats.

HTML is very useful if you want to publish your notebooks.

Merging Notebooks

Merging notebooks is very simple.

First install “nbmerge” with

```
pip install nbmerge
```

Then merge your files with

```
nbmerge file_1.ipynb file_2.ipynb file_3.ipynb > merged.ipynb
```

QUESTIONS?