**Preface**

**What Is Data Science?**

Data science comprises three distinct and overlapping areas: the skills of a statistician who knows how to model and summarize datasets (which are growing ever larger); the skills of a computer scientist who can design and use algorithms to efficiently store, process, and visualize this data; and the domain expertise—what we might think of as “classical” training in a subject—necessary both to formulate the right questions and to put their answers in context.

A diagram of data science

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**Why Python**

* NumPy for manipulation of homogeneous array-based data,
* Pandas for manipulation of heterogeneous and labeled data,
* SciPy for common scientific computing tasks,
* Matplotlib for publication-quality visualizations,
* IPython for interactive execution and sharing of code, Scikit-Learn for machine learning

**Jupyter: Beyond Normal Python**

**Getting Started in IPython and Jupyter**

* **IPython shell** for trying out short sequences of commands
* **Jupyter Notebook** for longer interactive analysis and for sharing content with others
* **Interactive development environments (IDEs)** like **Emacs** or **VSCode** for creating reusable Python packages.

**The IPython Shell**

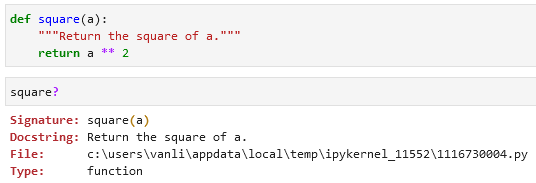
* Start the *IPython Shell* by typing ipython in the *Anaconda Prompt*.
* Launch Jupyter lab (?) $ jupyter lab

**Access documentation** with help() like help(len). The alternative is ? like len?. Get information on objects using ? like in the example below:

A screenshot of a computer

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You can also get information on functions or other objects you create like in the example below which has a docstring (a description of the function):



?? provides the source code of the object you are curious about:

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Use wildcard matching (character \*) to list every object in the namespace whose name ends with *Warning*:

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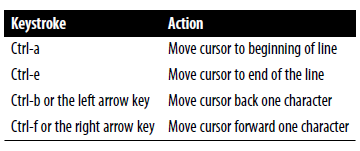
In the example below we area looking for a string method that contains the word *find* somewhere in its name:

A screenshot of a computer

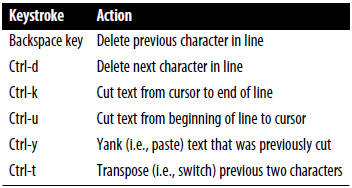
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**Keyboard Shortcuts in the IPython Shell**

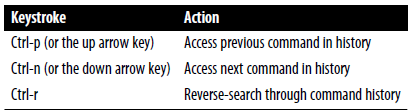
**Navigation Shortcuts**



**Text Entry Shortcuts**



**Command History Shortcuts**

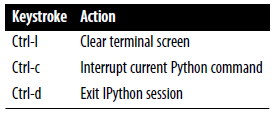


Use *Ctrl-r* to browse the search results. When you’re done press *Enter*.

A close up of text

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**Miscellaneous Shortcuts**



**Enhanced Interactive Features**

**IPython Magic Commands**

Magic commands are prefixed by the % character.

* **Line magics** are denoted by a single % prefix. They operate on a **single line of input**.
* **Cell magics** are denoted by a double %% prefix and operate on **multiple lines of input**.
* Magic commands documentation %magic.
* Quick and simple list of all available magic functions %lsmagic.

If you have a *.py* file you can execute it / run its script in IPython using %run filename.py:

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To time code execution use %timeit or %%timeit for multiple lines of code:

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You can check you input and output history using In and Out codes. You can also select specific steps like print(In[1]).

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A white background with red text

Description automatically generated

A black text on a white background

Description automatically generated

A screenshot of a computer program

Description automatically generated

An alternative to Out[20] is \_20:



Use print(\_) to get access to the previous output:

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You can also use print(\_\_) and print(\_\_\_) to get access to the second/third-to-last outputs.

If you want to suppress you output you can do it using ; at the end of the line:

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Description automatically generated

Use %history to get an overview of your commands, use %history -n to get an numbered overview of your commands. To select a command/commands add a number like 3-5:

A black screen with white text

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Description automatically generated

Other useful commands are %rerun (re-execute some portion of the command history) and %save (saves some set of the command history to a file).

**Quick Introduction to the Shell**

Some shell commands:



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echo, pwd, ls, cd, mkdir, mv

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A screenshot of a computer program

Description automatically generated

!echo

A screenshot of a computer

Description automatically generated!pwd !cd

A screenshot of a computer program

Description automatically generated%cd mkdir ls cp rm -r

**Debugging and Profiling**

**Controlling Exceptions using %xmode**

There are 3 formats for errors: Plain, Context, and Verbose.

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The last provides the most information but can be bulky.

**To launch a debugger** write %debug.

**Launch the Sdebugger automatically** whenever an exception is raised using

%xmode Plain

%pdb on

A computer code with text

Description automatically generated

**Partial list of debugging commands:**

A screenshot of a computer program

Description automatically generatedl(ist) h(elp) q(uit) c(ontinue) n(ext) <enter> p(rint) s(tep) r(eturn)

**Profiling and Timing Code**

%time Time the execution of a single statement

%timeit Time repeated execution of a single statement for more accuracy

%prun Run code with the profiler

%lprun Run code with the line-by-line profiler

%memit Measure the memory use of a single statement

%mprun Run code with the line-by-line memory profiler

%timeit

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%time

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%prun

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A close up of text

Description automatically generated

%lprun

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Description automatically generated%load\_ext line\_profiler %lprun -f

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%memit (is a memory-measuring equivalent of %timeit) and %mprun (memory-measuring equivalent of %lprun)

A white rectangular sign with black text

Description automatically generated pip install memory\_profiler

A white rectangular object with black text

Description automatically generated%load\_ext memory\_profiler

A white rectangular object with green text

Description automatically generated with medium confidence %memit

A close-up of a text

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A screenshot of a computer program

Description automatically generated%%file %mprun -f

**NumPy**

In some ways, NumPy arrays are like Python’s built-in *list* type, but NumPy arrays provide much more efficient storage and data operations as the arrays grow larger in size.

Check NumPy version: numpy.\_\_version\_\_

**Fixed-Type Arrays in Python**

Example of an array in Python:

A screenshot of a computer code

Description automatically generatedimport array, array.array



Python arrays objects provide efficient storage. NumPy adds to this efficient operations on that data.

**Creating Arrays from Python Lists**

NumPy arrays can only contain data of the same type. This is unlike Python lists.

NumPy arrays can be multidimensional. Python lists are always one-dimensional sequences.

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**Creating Arrays from Scratch**

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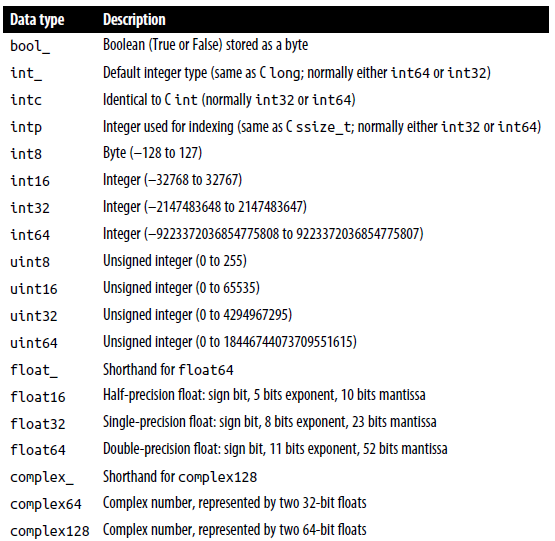
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**Specify data type when creating an array using dtype=’int16’ or dtype=np.int16:**

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**Standard NumPy data types:**



**NumPy Array Attributes**

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ndim, shape, size, dtype, default\_rng(seed= integers

**Array Slicing: Accessing Subarrays**

Follow this logic to access a slice of an array x:

x[start:stop:step]

If any of these are unspecified, they default to the values start=0, stop=<size of dimension>, step=1.



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Description automatically generatedreverse an array [::-1]

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Description automatically generatedreverse a multiarray [::-1, ::-1]

 first column of a multiarray [0, :]

 first row of a multiarray [0] or [0, :]



**Subarrays as no-copy views**

Unlike Python list slices, NumPy array slices are returned as views rather than copies of the array data.

In the example below if we modify the subarray *x2\_sub* the original array *x2* will also change.

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It can be advantageous when working with large datasets. We can access and process pieces of these datasets without the need to copy the underlying data buffer.

If you want to create a copy that can be changed without affecting the original data use the .copy() code:

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**Reshaping of arrays**

Use .reshape() to put if you want to put e.g. numbers from 1 to 9 in a 3 × 3 grid:

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Note that the size of the array should match the size of the reshaped array.

You can also use .reshape() to convert a one-dimensional array into…

…a two-dimensional row matrix: …or a column matrix:

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You can achieve the same using np.newaxis in the slicing index:

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**Array concatenation (combine multiple arrays into one)**

Use np.concatenate, np.vstack, and np.hstack to join two arrays.

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Concatenate a two-dimensional array along the first axis: …and among the second axis:

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When you have arrays of mixed dimensions you can use np.vstack and np.hstack:

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For higher-dimensional arrays np.dstack will stack arrays along the third axis.

**Array splitting (split a single array into multiple arrays)**

To split arrays use functions np.split, np.hsplit, np.vsplit.

Using np.split(array\_name, [splitting\_location(s)]):

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Splitting using np.hsplit and np.vsplit:

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Description automatically generated

For higher-dimensional arrays np.dsplit will split arrays along the third axis.

**NumPy universal functions (ufuncs)**

To make computation on NumPy arrays fast use vectorized operations that are generally implemented through universal functions (ufuncs). There are two types of ufuncs: unary and binary. Unary ufuncs operate on a single input while binary ufuncs operate on two inputs.

Arithmetic operators examples in NumPy:

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