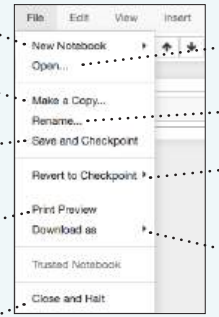
Python For Data Science *Cheat Sheet*

Jupyter Notebook

Learn More Python for Data Science Interactively at www.DataCamp.com

Saving/Loading Notebooks

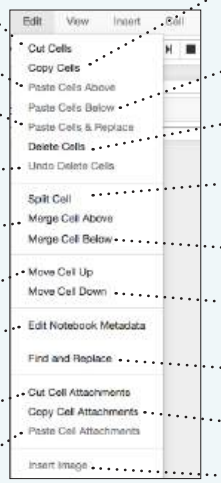


- Create new notebook
- Open an existing notebook
- Make a copy of the current notebook
- Rename notebook
- Save current notebook and record checkpoint
- Revert notebook to a previous checkpoint
- Preview of the printed notebook
- Download notebook as
  - IPython notebook
  - Python
  - HTML
  - Markdown
  - reST
  - LaTeX
  - PDF
- Close notebook & stop running any scripts

Writing Code And Text

Code and text are encapsulated by 3 basic cell types: markdown cells, code cells, and raw NBConvert cells.

Edit Cells



- Cut currently selected cells to clipboard
- Copy cells from clipboard to current cursor position
- Paste cells from clipboard above current cell
- Paste cells from clipboard below current cell
- Paste cells from clipboard on top of current cel
- Delete current cells
- Revert *"Delete Cells"* invocation
- Split up a cell from current cursor position
- Merge current cell with the one above
- Merge current cell with the one below
- Move current cell up
- Move current cell down
- Adjust metadata underlying the current notebook
- Find and replace in selected cells
- Remove cell attachments
- Copy attachments of current cell
- Paste attachments of current cell
- Insert image in selected cells

Insert Cells

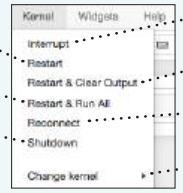
- Add new cell above the current one
- Add new cell below the current one

Working with Different Programming Languages

Kernels provide computation and communication with front-end interfaces like the notebooks. There are three main kernels:

IPython | IRkernel | IJulia

Installing Jupyter Notebook will automatically install the IPython kernel.

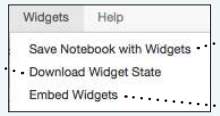


- Restart kernel
- Interrupt kernel
- Restart kernel & run all cells
- Interrupt kernel & clear all output
- Restart kernel & run all cells
- Connect back to a remote notebook
- Run other installed kernels

Widgets

Notebook widgets provide the ability to visualize and control changes in your data, often as a control like a slider, textbox, etc.

You can use them to build interactive GUIs for your notebooks or to synchronize stateful and stateless information between Python and JavaScript.



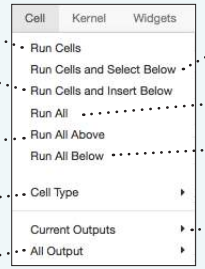
- Download serialized state of all widget models in use
- Save notebook with interactive widgets
- Embed current widgets

Command Mode:

Edit Mode:

1. Save and checkpoint
2. Insert cell below
3. Cut cell
4. Copy cell(s)
5. Paste cell(s) below
6. Move cell up
7. Move cell down
8. Run current cell
9. Interrupt kernel
10. Restart kernel
11. Display characteristics
12. Open command palette
13. Current kernel
14. Kernel status
15. Log out from notebook server

Executing Cells

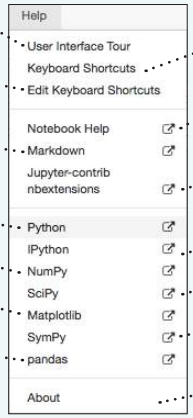


- Run selected cell(s)
- Run current cells down and create a new one below
- Run current cells down and create a new one above
- Run all cells
- Run all cells above the current cell
- Run all cells below the current cell
- Change the cell type of current cell
- toggle, toggle scrolling and clear current outputs
- toggle, toggle scrolling and clear all output

View Cells

- Toggle display of Jupyter logo and filename
- Toggle display of toolbar
- Toggle display of cell action icons:
  - None
  - Edit metadata
  - Raw cell format
  - Slideshow
  - Attachments
  - Tags
- Toggle line numbers in cells

Asking For Help



- Walk through a UI tour
- List of built-in keyboard shortcuts
- Edit the built-in keyboard shortcuts
- Notebook help topics
- Description of markdown available in notebook
- Information on unofficial Jupyter Notebook extensions
- Python help topics
- IPython help topics
- NumPy help topics
- SciPy help topics
- Matplotlib help topics
- SymPy help topics
- Pandas help topics
- About Jupyter Notebook

Python For Data Science *Cheat Sheet*

Python Basics

Learn More Python for Data Science Interactively at www.datacamp.com

Variables and Data Types

Variable Assignment

```
>>> x=5
>>> x
 5
```

Calculations With Variables

`>>> x+2` → `7`	Sum of two variables
`>>> x-2` → `3`	Subtraction of two variables
`>>> x*2` → `10`	Multiplication of two variables
`>>> x**2` → `25`	Exponentiation of a variable
`>>> x%2` → `1`	Remainder of a variable
`>>> x/float(2)` → `2.5`	Division of a variable

Types and Type Conversion

`str()`	`'5', '3.45', 'True'`	Variables to strings
`int()`	`5, 3, 1`	Variables to integers
`float()`	`5.0, 1.0`	Variables to floats
`bool()`	`True, True, True`	Variables to booleans

Asking For Help

```
>>> help(str)
```

Lists

Also see NumPy Arrays

```
>>> a = 'is'
>>> b = 'nice'
>>> my_list = ['my', 'list', a, b]
>>> my_list2 = [[4,5,6,7], [3,4,5,6]]
```

Selecting List Elements

Index starts at 0

Subset	
`>>> my_list[1]`	Select item at index 1
`>>> my_list[-3]`	Select 3rd last item
Slice	
`>>> my_list[1:3]`	Select items at index 1 and 2
`>>> my_list[1:]`	Select items after index 0
`>>> my_list[:3]`	Select items before index 3
`>>> my_list[:]`	Copy my_list
Subset Lists of Lists	
`>>> my_list2[1][0]`	my_list[list][itemOfList]
`>>> my_list2[1][:2]`	

List Operations

```
>>> my_list + my_list
['my', 'list', 'is', 'nice', 'my', 'list', 'is', 'nice']
>>> my_list * 2
['my', 'list', 'is', 'nice', 'my', 'list', 'is', 'nice']
>>> my_list2 > 4
True
```

List Methods

`>>> my_list.index(a)`	Get the index of an item
`>>> my_list.count(a)`	Count an item
`>>> my_list.append('!')`	Append an item at a time
`>>> my_list.remove('!')`	Remove an item
`>>> del(my_list[0:1])`	Remove an item
`>>> my_list.reverse()`	Reverse the list
`>>> my_list.extend('!')`	Append an item
`>>> my_list.pop(-1)`	Remove an item
`>>> my_list.insert(0,'!')`	Insert an item
`>>> my_list.sort()`	Sort the list

Libraries

Import libraries

```
>>> import numpy
>>> import numpy as np
```

Selective import

```
>>> from math import pi
```

pandas — Data analysis

learn — Machine learning

NumPy — Scientific computing

matplotlib — 2D plotting

Install Python

ANACONDA — Leading open data science platform powered by Python

spyder — Free IDE that is included with Anaconda

jupyter — Create and share documents with live code, visualizations, text, ...

Numpy Arrays

Also see Lists

```
>>> my_list = [1, 2, 3, 4]
>>> my_array = np.array(my_list)
>>> my_2darray = np.array([[1,2,3],[4,5,6]])
```

Selecting Numpy Array Elements

Index starts at 0

Subset	
`>>> my_array[1]` → `2`	Select item at index 1
Slice	
`>>> my_array[0:2]` → `array([1, 2])`	Select items at index 0 and 1
Subset 2D Numpy arrays	
`>>> my_2darray[:,0]` → `array([1, 4])`	my_2darray[rows, columns]

Numpy Array Operations

```
>>> my_array > 3
array([False, False, False,  True], dtype=bool)
>>> my_array * 2
array([2, 4, 6, 8])
>>> my_array + np.array([5, 6, 7, 8])
array([6, 8, 10, 12])
```

Numpy Array Functions

`>>> my_array.shape`	Get the dimensions of the array
`>>> np.append(other_array)`	Append items to an array
`>>> np.insert(my_array, 1, 5)`	Insert items in an array
`>>> np.delete(my_array,[1])`	Delete items in an array
`>>> np.mean(my_array)`	Mean of the array
`>>> np.median(my_array)`	Median of the array
`>>> my_array.corrcoef()`	Correlation coefficient
`>>> np.std(my_array)`	Standard deviation

Strings

```
>>> my_string = 'thisStringIsAwesome'
>>> my_string
'thisStringIsAwesome'
```

String Operations

```
>>> my_string * 2
'thisStringIsAwesomethisStringIsAwesome'
>>> my_string + 'Innit'
'thisStringIsAwesomeInnit'
>>> 'm' in my_string
True
```

String Operations

Index starts at 0

```
>>> my_string[3]
>>> my_string[4:9]
```

String Methods

`>>> my_string.upper()`	String to uppercase
`>>> my_string.lower()`	String to lowercase
`>>> my_string.count('w')`	Count String elements
`>>> my_string.replace('e', 'i')`	Replace String elements
`>>> my_string.strip()`	Strip whitespaces

Beginner's Python Cheat Sheet

Variables and Strings

Variables are used to store values. A string is a series of characters, surrounded by single or double quotes.

Hello world

```
print("Hello world!")
```

Hello world with a variable

```
msg = "Hello world!"
print(msg)
```

Concatenation (combining strings)

```
first_name = 'albert'
last_name = 'einstein'
full_name = first_name + ' ' + last_name
print(full_name)
```

Lists

A list stores a series of items in a particular order. You access items using an index, or within a loop.

Make a list

```
bikes = ['trek', 'redline', 'giant']
```

Get the first item in a list

```
first_bike = bikes[0]
```

Get the last item in a list

```
last_bike = bikes[-1]
```

Looping through a list

```
for bike in bikes:
    print(bike)
```

Adding items to a list

```
bikes = []
bikes.append('trek')
bikes.append('redline')
bikes.append('giant')
```

Making numerical lists

```
squares = []
for x in range(1, 11):
    squares.append(x**2)
```

Lists (cont.)

List comprehensions

```
squares = [x**2 for x in range(1, 11)]
```

Slicing a list

```
finishers = ['sam', 'bob', 'ada', 'bea']
first_two = finishers[:2]
```

Copying a list

```
copy_of_bikes = bikes[:]
```

Tuples

Tuples are similar to lists, but the items in a tuple can't be modified.

Making a tuple

```
dimensions = (1920, 1080)
```

If statements

If statements are used to test for particular conditions and respond appropriately.

Conditional tests

```
equals            x == 42
not equal         x != 42
greater than      x > 42
  or equal to     x >= 42
less than         x < 42
  or equal to     x <= 42
```

Conditional test with lists

```
'trek' in bikes
'surly' not in bikes
```

Assigning boolean values

```
game_active = True
can_edit = False
```

A simple if test

```
if age >= 18:
    print("You can vote!")
```

If-elif-else statements

```
if age < 4:
    ticket_price = 0
elif age < 18:
    ticket_price = 10
else:
    ticket_price = 15
```

Dictionaries

Dictionaries store connections between pieces of information. Each item in a dictionary is a key-value pair.

A simple dictionary

```
alien = {'color': 'green', 'points': 5}
```

Accessing a value

```
print("The alien's color is " + alien['color'])
```

Adding a new key-value pair

```
alien['x_position'] = 0
```

Looping through all key-value pairs

```
fav_numbers = {'eric': 17, 'ever': 4}
for name, number in fav_numbers.items():
    print(name + ' loves ' + str(number))
```

Looping through all keys

```
fav_numbers = {'eric': 17, 'ever': 4}
for name in fav_numbers.keys():
    print(name + ' loves a number')
```

Looping through all the values

```
fav_numbers = {'eric': 17, 'ever': 4}
for number in fav_numbers.values():
    print(str(number) + ' is a favorite')
```

User input

Your programs can prompt the user for input. All input is stored as a string.

Prompting for a value

```
name = input("What's your name? ")
print("Hello, " + name + "!")
```

Prompting for numerical input

```
age = input("How old are you? ")
age = int(age)

pi = input("What's the value of pi? ")
pi = float(pi)
```

While loops

A while loop repeats a block of code as long as a certain condition is true.

A simple while loop

```
current_value = 1
while current_value <= 5:
    print(current_value)
    current_value += 1
```

Letting the user choose when to quit

```
msg = ''
while msg != 'quit':
    msg = input("What's your message? ")
    print(msg)
```

Functions

Functions are named blocks of code, designed to do one specific job. Information passed to a function is called an argument, and information received by a function is called a parameter.

A simple function

```
def greet_user():
    """Display a simple greeting."""
    print("Hello!")

greet_user()
```

Passing an argument

```
def greet_user(username):
    """Display a personalized greeting."""
    print("Hello, " + username + "!")

greet_user('jesse')
```

Default values for parameters

```
def make_pizza(topping='bacon'):
    """Make a single-topping pizza."""
    print("Have a " + topping + " pizza!")

make_pizza()
make_pizza('pepperoni')
```

Returning a value

```
def add_numbers(x, y):
    """Add two numbers and return the sum."""
    return x + y

sum = add_numbers(3, 5)
print(sum)
```

Classes

A class defines the behavior of an object and the kind of information an object can store. The information in a class is stored in attributes, and functions that belong to a class are called methods. A child class inherits the attributes and methods from its parent class.

Creating a dog class

```
class Dog():
    """Represent a dog."""

    def __init__(self, name):
        """Initialize dog object."""
        self.name = name

    def sit(self):
        """Simulate sitting."""
        print(self.name + " is sitting.")

my_dog = Dog('Peso')

print(my_dog.name + " is a great dog!")
my_dog.sit()
```

Inheritance

```
class SARDog(Dog):
    """Represent a search dog."""

    def __init__(self, name):
        """Initialize the sardog."""
        super().__init__(name)

    def search(self):
        """Simulate searching."""
        print(self.name + " is searching.")

my_dog = SARDog('Willie')

print(my_dog.name + " is a search dog.")
my_dog.sit()
my_dog.search()
```

Infinite Skills

If you had infinite programming skills, what would you build?

As you're learning to program, it's helpful to think about the real-world projects you'd like to create. It's a good habit to keep an "ideas" notebook that you can refer to whenever you want to start a new project. If you haven't done so already, take a few minutes and describe three projects you'd like to create.

Working with files

Your programs can read from files and write to files. Files are opened in read mode ('r') by default, but can also be opened in write mode ('w') and append mode ('a').

Reading a file and storing its lines

```
filename = 'siddhartha.txt'
with open(filename) as file_object:
    lines = file_object.readlines()

for line in lines:
    print(line)
```

Writing to a file

```
filename = 'journal.txt'
with open(filename, 'w') as file_object:
    file_object.write("I love programming.")
```

Appending to a file

```
filename = 'journal.txt'
with open(filename, 'a') as file_object:
    file_object.write("\nI love making games.")
```

Exceptions

Exceptions help you respond appropriately to errors that are likely to occur. You place code that might cause an error in the try block. Code that should run in response to an error goes in the except block. Code that should run only if the try block was successful goes in the else block.

Catching an exception

```
prompt = "How many tickets do you need? "
num_tickets = input(prompt)

try:
    num_tickets = int(num_tickets)
except ValueError:
    print("Please try again.")
else:
    print("Your tickets are printing.")
```

Zen of Python

Simple is better than complex

If you have a choice between a simple and a complex solution, and both work, use the simple solution. Your code will be easier to maintain, and it will be easier for you and others to build on that code later on.

Beginner's Python Cheat Sheet - Lists

What are lists?

A list stores a series of items in a particular order. Lists allow you to store sets of information in one place, whether you have just a few items or millions of items. Lists are one of Python's most powerful features readily accessible to new programmers, and they tie together many important concepts in programming.

Defining a list

Use square brackets to define a list, and use commas to separate individual items in the list. Use plural names for lists, to make your code easier to read.

Making a list

```
users = ['val', 'bob', 'mia', 'ron', 'ned']
```

Accessing elements

Individual elements in a list are accessed according to their position, called the index. The index of the first element is 0, the index of the second element is 1, and so forth. Negative indices refer to items at the end of the list. To get a particular element, write the name of the list and then the index of the element in square brackets.

Getting the first element

```
first_user = users[0]
```

Getting the second element

```
second_user = users[1]
```

Getting the last element

```
newest_user = users[-1]
```

Modifying individual items

Once you've defined a list, you can change individual elements in the list. You do this by referring to the index of the item you want to modify.

Changing an element

```
users[0] = 'valerie'
users[-2] = 'ronald'
```

Adding elements

You can add elements to the end of a list, or you can insert them wherever you like in a list.

Adding an element to the end of the list

```
users.append('amy')
```

Starting with an empty list

```
users = []
users.append('val')
users.append('bob')
users.append('mia')
```

Inserting elements at a particular position

```
users.insert(0, 'joe')
users.insert(3, 'bea')
```

Removing elements

You can remove elements by their position in a list, or by the value of the item. If you remove an item by its value, Python removes only the first item that has that value.

Deleting an element by its position

```
del users[-1]
```

Removing an item by its value

```
users.remove('mia')
```

Popping elements

If you want to work with an element that you're removing from the list, you can "pop" the element. If you think of the list as a stack of items, pop() takes an item off the top of the stack. By default pop() returns the last element in the list, but you can also pop elements from any position in the list.

Pop the last item from a list

```
most_recent_user = users.pop()
print(most_recent_user)
```

Pop the first item in a list

```
first_user = users.pop(0)
print(first_user)
```

List length

The len() function returns the number of items in a list.

Find the length of a list

```
num_users = len(users)
print("We have " + str(num_users) + " users.")
```

Sorting a list

The sort() method changes the order of a list permanently. The sorted() function returns a copy of the list, leaving the original list unchanged. You can sort the items in a list in alphabetical order, or reverse alphabetical order. You can also reverse the original order of the list. Keep in mind that lowercase and uppercase letters may affect the sort order.

Sorting a list permanently

```
users.sort()
```

Sorting a list permanently in reverse alphabetical order

```
users.sort(reverse=True)
```

Sorting a list temporarily

```
print(sorted(users))
print(sorted(users, reverse=True))
```

Reversing the order of a list

```
users.reverse()
```

Looping through a list

Lists can contain millions of items, so Python provides an efficient way to loop through all the items in a list. When you set up a loop, Python pulls each item from the list one at a time and stores it in a temporary variable, which you provide a name for. This name should be the singular version of the list name.

The indented block of code makes up the body of the loop, where you can work with each individual item. Any lines that are not indented run after the loop is completed.

Printing all items in a list

```
for user in users:
    print(user)
```

Printing a message for each item, and a separate message afterwards

```
for user in users:
    print("Welcome, " + user + "!")

print("Welcome, we're glad to see you all!")
```

The range() function

You can use the range() function to work with a set of numbers efficiently. The range() function starts at 0 by default, and stops one number below the number passed to it. You can use the list() function to efficiently generate a large list of numbers.

Printing the numbers 0 to 1000

```
for number in range(1001):
    print(number)
```

Printing the numbers 1 to 1000

```
for number in range(1, 1001):
    print(number)
```

Making a list of numbers from 1 to a million

```
numbers = list(range(1, 1000001))
```

Simple statistics

There are a number of simple statistics you can run on a list containing numerical data.

Finding the minimum value in a list

```
ages = [93, 99, 66, 17, 85, 1, 35, 82, 2, 77]
youngest = min(ages)
```

Finding the maximum value

```
ages = [93, 99, 66, 17, 85, 1, 35, 82, 2, 77]
oldest = max(ages)
```

Finding the sum of all values

```
ages = [93, 99, 66, 17, 85, 1, 35, 82, 2, 77]
total_years = sum(ages)
```

Slicing a list

You can work with any set of elements from a list. A portion of a list is called a slice. To slice a list start with the index of the first item you want, then add a colon and the index after the last item you want. Leave off the first index to start at the beginning of the list, and leave off the last index to slice through the end of the list.

Getting the first three items

```
finishers = ['kai', 'abe', 'ada', 'gus', 'zoe']
first_three = finishers[:3]
```

Getting the middle three items

```
middle_three = finishers[1:4]
```

Getting the last three items

```
last_three = finishers[-3:]
```

Copying a list

To copy a list make a slice that starts at the first item and ends at the last item. If you try to copy a list without using this approach, whatever you do to the copied list will affect the original list as well.

Making a copy of a list

```
finishers = ['kai', 'abe', 'ada', 'gus', 'zoe']
copy_of_finishers = finishers[:]
```

List comprehensions

You can use a loop to generate a list based on a range of numbers or on another list. This is a common operation, so Python offers a more efficient way to do it. List comprehensions may look complicated at first; if so, use the for loop approach until you're ready to start using comprehensions.

To write a comprehension, define an expression for the values you want to store in the list. Then write a for loop to generate input values needed to make the list.

Using a loop to generate a list of square numbers

```
squares = []
for x in range(1, 11):
    square = x**2
    squares.append(square)
```

Using a comprehension to generate a list of square numbers

```
squares = [x**2 for x in range(1, 11)]
```

Using a loop to convert a list of names to upper case

```
names = ['kai', 'abe', 'ada', 'gus', 'zoe']

upper_names = []
for name in names:
    upper_names.append(name.upper())
```

Using a comprehension to convert a list of names to upper case

```
names = ['kai', 'abe', 'ada', 'gus', 'zoe']

upper_names = [name.upper() for name in names]
```

Styling your code

Readability counts

- Use four spaces per indentation level.
- Keep your lines to 79 characters or fewer.
- Use single blank lines to group parts of your program visually.

Tuples

A tuple is like a list, except you can't change the values in a tuple once it's defined. Tuples are good for storing information that shouldn't be changed throughout the life of a program. Tuples are designated by parentheses instead of square brackets. (You can overwrite an entire tuple, but you can't change the individual elements in a tuple.)

Defining a tuple

```
dimensions = (800, 600)
```

Looping through a tuple

```
for dimension in dimensions:
    print(dimension)
```

Overwriting a tuple

```
dimensions = (800, 600)
print(dimensions)

dimensions = (1200, 900)
```

Visualizing your code

When you're first learning about data structures such as lists, it helps to visualize how Python is working with the information in your program. pythontutor.com is a great tool for seeing how Python keeps track of the information in a list. Try running the following code on pythontutor.com, and then run your own code.

Build a list and print the items in the list

```
dogs = []
dogs.append('willie')
dogs.append('hootz')
dogs.append('peso')
dogs.append('goblin')

for dog in dogs:
    print("Hello " + dog + "!")
print("I love these dogs!")

print("\nThese were my first two dogs:")
old_dogs = dogs[:2]
for old_dog in old_dogs:
    print(old_dog)

del dogs[0]
dogs.remove('peso')
print(dogs)
```

More cheat sheets available at
ehmatthes.github.io/pcc/

Beginner's Python Cheat Sheet — Dictionaries

What are dictionaries?

Python's dictionaries allow you to connect pieces of related information. Each piece of information in a dictionary is stored as a key-value pair. When you provide a key, Python returns the value associated with that key. You can loop through all the key-value pairs, all the keys, or all the values.

Defining a dictionary

Use curly braces to define a dictionary. Use colons to connect keys and values, and use commas to separate individual key-value pairs.

Making a dictionary

```
alien_0 = {'color': 'green', 'points': 5}
```

Accessing values

To access the value associated with an individual key give the name of the dictionary and then place the key in a set of square brackets. If the key you're asking for is not in the dictionary, an error will occur.

You can also use the get() method, which returns None instead of an error if the key doesn't exist. You can also specify a default value to use if the key is not in the dictionary.

Getting the value associated with a key

```
alien_0 = {'color': 'green', 'points': 5}

print(alien_0['color'])
print(alien_0['points'])
```

Getting the value with get()

```
alien_0 = {'color': 'green'}

alien_color = alien_0.get('color')
alien_points = alien_0.get('points', 0)

print(alien_color)
print(alien_points)
```

Adding new key-value pairs

You can store as many key-value pairs as you want in a dictionary, until your computer runs out of memory. To add a new key-value pair to an existing dictionary give the name of the dictionary and the new key in square brackets, and set it equal to the new value.

This also allows you to start with an empty dictionary and add key-value pairs as they become relevant.

Adding a key-value pair

```
alien_0 = {'color': 'green', 'points': 5}

alien_0['x'] = 0
alien_0['y'] = 25
alien_0['speed'] = 1.5
```

Adding to an empty dictionary

```
alien_0 = {}
alien_0['color'] = 'green'
alien_0['points'] = 5
```

Modifying values

You can modify the value associated with any key in a dictionary. To do so give the name of the dictionary and enclose the key in square brackets, then provide the new value for that key.

Modifying values in a dictionary

```
alien_0 = {'color': 'green', 'points': 5}
print(alien_0)

# Change the alien's color and point value.
alien_0['color'] = 'yellow'
alien_0['points'] = 10
print(alien_0)
```

Removing key-value pairs

You can remove any key-value pair you want from a dictionary. To do so use the del keyword and the dictionary name, followed by the key in square brackets. This will delete the key and its associated value.

Deleting a key-value pair

```
alien_0 = {'color': 'green', 'points': 5}
print(alien_0)

del alien_0['points']
print(alien_0)
```

Visualizing dictionaries

Try running some of these examples on pythontutor.com.

Looping through a dictionary

You can loop through a dictionary in three ways: you can loop through all the key-value pairs, all the keys, or all the values.

A dictionary only tracks the connections between keys and values; it doesn't track the order of items in the dictionary. If you want to process the information in order, you can sort the keys in your loop.

Looping through all key-value pairs

```
# Store people's favorite languages.
fav_languages = {
    'jen': 'python',
    'sarah': 'c',
    'edward': 'ruby',
    'phil': 'python',
    }

# Show each person's favorite language.
for name, language in fav_languages.items():
    print(name + ": " + language)
```

Looping through all the keys

```
# Show everyone who's taken the survey.
for name in fav_languages.keys():
    print(name)
```

Looping through all the values

```
# Show all the languages that have been chosen.
for language in fav_languages.values():
    print(language)
```

Looping through all the keys in order

```
# Show each person's favorite language,
#   in order by the person's name.
for name in sorted(fav_languages.keys()):
    print(name + ": " + language)
```

Dictionary length

You can find the number of key-value pairs in a dictionary.

Finding a dictionary's length

```
num_responses = len(fav_languages)
```

Nesting — A list of dictionaries

It's sometimes useful to store a set of dictionaries in a list; this is called nesting.

Storing dictionaries in a list

```
# Start with an empty list.
users = []

# Make a new user, and add them to the list.
new_user = {
    'last': 'fermi',
    'first': 'enrico',
    'username': 'efermi',
    }
users.append(new_user)

# Make another new user, and add them as well.
new_user = {
    'last': 'curie',
    'first': 'marie',
    'username': 'mcurie',
    }
users.append(new_user)

# Show all information about each user.
for user_dict in users:
    for k, v in user_dict.items():
        print(k + ": " + v)
    print("\n")
```

You can also define a list of dictionaries directly, without using append():

```
# Define a list of users, where each user
#   is represented by a dictionary.
users = [
    {
        'last': 'fermi',
        'first': 'enrico',
        'username': 'efermi',
    },
    {
        'last': 'curie',
        'first': 'marie',
        'username': 'mcurie',
    },
]

# Show all information about each user.
for user_dict in users:
    for k, v in user_dict.items():
        print(k + ": " + v)
    print("\n")
```

Nesting — Lists in a dictionary

Storing a list inside a dictionary alows you to associate more than one value with each key.

Storing lists in a dictionary

```
# Store multiple languages for each person.
fav_languages = {
    'jen': ['python', 'ruby'],
    'sarah': ['c'],
    'edward': ['ruby', 'go'],
    'phil': ['python', 'haskell'],
}

# Show all responses for each person.
for name, langs in fav_languages.items():
    print(name + ": ")
    for lang in langs:
        print("- " + lang)
```

Nesting — A dictionary of dictionaries

You can store a dictionary inside another dictionary. In this case each value associated with a key is itself a dictionary.

Storing dictionaries in a dictionary

```
users = {
    'aeinstein': {
        'first': 'albert',
        'last': 'einstein',
        'location': 'princeton',
        },
    'mcurie': {
        'first': 'marie',
        'last': 'curie',
        'location': 'paris',
        },
    }

for username, user_dict in users.items():
    print("\nUsername: " + username)
    full_name = user_dict['first'] + " "
    full_name += user_dict['last']
    location = user_dict['location']

    print("\tFull name: " + full_name.title())
    print("\tLocation: " + location.title())
```

Levels of nesting

Nesting is extremely useful in certain situations. However, be aware of making your code overly complex. If you're nesting items much deeper than what you see here there are probably simpler ways of managing your data, such as using classes.

Using an OrderedDict

Standard Python dictionaries don't keep track of the order in which keys and values are added; they only preserve the association between each key and its value. If you want to preserve the order in which keys and values are added, use an OrderedDict.

Preserving the order of keys and values

```
from collections import OrderedDict

# Store each person's languages, keeping
#  track of who respoded first.
fav_languages = OrderedDict()

fav_languages['jen'] = ['python', 'ruby']
fav_languages['sarah'] = ['c']
fav_languages['edward'] = ['ruby', 'go']
fav_languages['phil'] = ['python', 'haskell']

# Display the results, in the same order they
#  were entered.
for name, langs in fav_languages.items():
    print(name + ":")
    for lang in langs:
        print("- " + lang)
```

Generating a million dictionaries

You can use a loop to generate a large number of dictionaries efficiently, if all the dictionaries start out with similar data.

A million aliens

```
aliens = []

# Make a million green aliens, worth 5 points
#  each. Have them all start in one row.
for alien_num in range(1000000):
    new_alien = {}
    new_alien['color'] = 'green'
    new_alien['points'] = 5
    new_alien['x'] = 20 * alien_num
    new_alien['y'] = 0
    aliens.append(new_alien)

# Prove the list contains a million aliens.
num_aliens = len(aliens)

print("Number of aliens created:")
print(num_aliens)
```

Beginner's Python Cheat Sheet — If Statements and While Loops

What are if statements? What are while loops?

If statements allow you to examine the current state of a program and respond appropriately to that state. You can write a simple if statement that checks one condition, or you can create a complex series of if statements that idenitfy the exact conditions you're looking for.

While loops run as long as certain conditions remain true. You can use while loops to let your programs run as long as your users want them to.

Conditional Tests

A conditional test is an expression that can be evaluated as True or False. Python uses the values True and False to decide whether the code in an if statement should be executed.

Checking for equality

A single equal sign assigns a value to a variable. A double equal sign (==) checks whether two values are equal.

```
>>> car = 'bmw'
>>> car == 'bmw'
True
>>> car = 'audi'
>>> car == 'bmw'
False
```

Ignoring case when making a comparison

```
>>> car = 'Audi'
>>> car.lower() == 'audi'
True
```

Checking for inequality

```
>>> topping = 'mushrooms'
>>> topping != 'anchovies'
True
```

Numerical comparisons

Testing numerical values is similar to testing string values.

Testing equality and inequality

```
>>> age = 18
>>> age == 18
True
>>> age != 18
False
```

Comparison operators

```
>>> age = 19
>>> age < 21
True
>>> age <= 21
True
>>> age > 21
False
>>> age >= 21
False
```

Checking multiple conditions

You can check multiple conditions at the same time. The and operator returns True if all the conditions listed are True. The or operator returns True if any condition is True.

Using and to check multiple conditions

```
>>> age_0 = 22
>>> age_1 = 18
>>> age_0 >= 21 and age_1 >= 21
False
>>> age_1 = 23
>>> age_0 >= 21 and age_1 >= 21
True
```

Using or to check multiple conditions

```
>>> age_0 = 22
>>> age_1 = 18
>>> age_0 >= 21 or age_1 >= 21
True
>>> age_0 = 18
>>> age_0 >= 21 or age_1 >= 21
False
```

Boolean values

A boolean value is either True or False. Variables with boolean values are often used to keep track of certain conditions within a program.

Simple boolean values

```
game_active = True
can_edit = False
```

If statements

Several kinds of if statements exist. Your choice of which to use depends on the number of conditions you need to test. You can have as many elif blocks as you need, and the else block is always optional.

Simple if statement

```
age = 19

if age >= 18:
    print("You're old enough to vote!")
```

If-else statements

```
age = 17

if age >= 18:
    print("You're old enough to vote!")
else:
    print("You can't vote yet.")
```

The if-elif-else chain

```
age = 12

if age < 4:
   price = 0
elif age < 18:
    price = 5
else:
    price = 10

print("Your cost is $" + str(price) + ".")
```

Conditional tests with lists

You can easily test whether a certain value is in a list. You can also test whether a list is empty before trying to loop through the list.

Testing if a value is in a list

```
>>> players = ['al', 'bea', 'cyn', 'dale']
>>> 'al' in players
True
>>> 'eric' in players
False
```

Conditional tests with lists (cont.)

Testing if a value is not in a list

```
banned_users = ['ann', 'chad', 'dee']
user = 'erin'

if user not in banned_users:
    print("You can play!")
```

Checking if a list is empty

```
players = []

if players:
    for player in players:
        print("Player: " + player.title())
else:
    print("We have no players yet!")
```

Accepting input

You can allow your users to enter input using the input() statement. In Python 3, all input is stored as a string.

Simple input

```
name = input("What's your name? ")
print("Hello, " + name + ".")
```

Accepting numerical input

```
age = input("How old are you? ")
age = int(age)

if age >= 18:
    print("\nYou can vote!")
else:
    print("\nYou can't vote yet.")
```

Accepting input in Python 2.7

Use raw_input() in Python 2.7. This function interprets all input as a string, just as input() does in Python 3.

```
name = raw_input("What's your name? ")
print("Hello, " + name + ".")
```

While loops

A while loop repeats a block of code as long as a condition is True.

Counting to 5

```
current_number = 1

while current_number <= 5:
    print(current_number)
    current_number += 1
```

While loops (cont.)

Letting the user choose when to quit

```
prompt = "\nTell me something, and I'll "
prompt += "repeat it back to you."
prompt += "\nEnter 'quit' to end the program. "

message = ""
while message != 'quit':
    message = input(prompt)

    if message != 'quit':
        print(message)
```

Using a flag

```
prompt = "\nTell me something, and I'll "
prompt += "repeat it back to you."
prompt += "\nEnter 'quit' to end the program. "

active = True
while active:
    message = input(prompt)

    if message == 'quit':
        active = False
    else:
        print(message)
```

Using break to exit a loop

```
prompt = "\nWhat cities have you visited?"
prompt += "\nEnter 'quit' when you're done. "

while True:
    city = input(prompt)

    if city == 'quit':
        break
    else:
        print("I've been to " + city + "!")
```

Accepting input with Sublime Text

Sublime Text doesn't run programs that prompt the user for input. You can use Sublime Text to write programs that prompt for input, but you'll need to run these programs from a terminal.

Breaking out of loops

You can use the break statement and the continue statement with any of Python's loops. For example you can use break to quit a for loop that's working through a list or a dictionary. You can use continue to skip over certain items when looping through a list or dictionary as well.

While loops (cont.)

Using continue in a loop

```
banned_users = ['eve', 'fred', 'gary', 'helen']

prompt = "\nAdd a player to your team."
prompt += "\nEnter 'quit' when you're done. "

players = []
while True:
    player = input(prompt)
    if player == 'quit':
        break
    elif player in banned_users:
        print(player + " is banned!")
        continue
    else:
        players.append(player)

print("\nYour team:")
for player in players:
    print(player)
```

Avoiding infinite loops

Every while loop needs a way to stop running so it won't continue to run forever. If there's no way for the condition to become False, the loop will never stop running.

An infinite loop

```
while True:
    name = input("\nWho are you? ")
    print("Nice to meet you, " + name + "!")
```

Removing all instances of a value from a list

The remove() method removes a specific value from a list, but it only removes the first instance of the value you provide. You can use a while loop to remove all instances of a particular value.

Removing all cats from a list of pets

```
pets = ['dog', 'cat', 'dog', 'fish', 'cat',
        'rabbit', 'cat']
print(pets)

while 'cat' in pets:
    pets.remove('cat')

print(pets)
```

More cheat sheets available at
ehmatthes.github.io/pcc/

Beginner's Python Cheat Sheet — Functions

What are functions?

Functions are named blocks of code designed to do one specific job. Functions allow you to write code once that can then be run whenever you need to accomplish the same task. Functions can take in the information they need, and return the information they generate. Using functions effectively makes your programs easier to write, read, test, and fix.

Defining a function

The first line of a function is its definition, marked by the keyword def. The name of the function is followed by a set of parentheses and a colon. A docstring, in triple quotes, describes what the function does. The body of a function is indented one level.

To call a function, give the name of the function followed by a set of parentheses.

Making a function

```
def greet_user():
    """Display a simple greeting."""
    print("Hello!")

greet_user()
```

Passing information to a function

Information that's passed to a function is called an argument; information that's received by a function is called a parameter. Arguments are included in parentheses after the function's name, and parameters are listed in parentheses in the function's definition.

Passing a single argument

```
def greet_user(username):
    """Display a simple greeting."""
    print("Hello, " + username + "!")

greet_user('jesse')
greet_user('diana')
greet_user('brandon')
```

Positional and keyword arguments

The two main kinds of arguments are positional and keyword arguments. When you use positional arguments Python matches the first argument in the function call with the first parameter in the function definition, and so forth.

With keyword arguments, you specify which parameter each argument should be assigned to in the function call. When you use keyword arguments, the order of the arguments doesn't matter.

Using positional arguments

```
def describe_pet(animal, name):
    """Display information about a pet."""
    print("\nI have a " + animal + ".")
    print("Its name is " + name + ".")

describe_pet('hamster', 'harry')
describe_pet('dog', 'willie')
```

Using keyword arguments

```
def describe_pet(animal, name):
    """Display information about a pet."""
    print("\nI have a " + animal + ".")
    print("Its name is " + name + ".")

describe_pet(animal='hamster', name='harry')
describe_pet(name='willie', animal='dog')
```

Default values

You can provide a default value for a parameter. When function calls omit this argument the default value will be used. Parameters with default values must be listed after parameters without default values in the function's definition so positional arguments can still work correctly.

Using a default value

```
def describe_pet(name, animal='dog'):
    """Display information about a pet."""
    print("\nI have a " + animal + ".")
    print("Its name is " + name + ".")

describe_pet('harry', 'hamster')
describe_pet('willie')
```

Using None to make an argument optional

```
def describe_pet(animal, name=None):
    """Display information about a pet."""
    print("\nI have a " + animal + ".")
    if name:
        print("Its name is " + name + ".")

describe_pet('hamster', 'harry')
describe_pet('snake')
```

Return values

A function can return a value or a set of values. When a function returns a value, the calling line must provide a variable in which to store the return value. A function stops running when it reaches a return statement.

Returning a single value

```
def get_full_name(first, last):
    """Return a neatly formatted full name."""
    full_name = first + ' ' + last
    return full_name.title()

musician = get_full_name('jimi', 'hendrix')
print(musician)
```

Returning a dictionary

```
def build_person(first, last):
    """Return a dictionary of information
    about a person.
    """
    person = {'first': first, 'last': last}
    return person

musician = build_person('jimi', 'hendrix')
print(musician)
```

Returning a dictionary with optional values

```
def build_person(first, last, age=None):
    """Return a dictionary of information
    about a person.
    """
    person = {'first': first, 'last': last}
    if age:
        person['age'] = age
    return person

musician = build_person('jimi', 'hendrix', 27)
print(musician)

musician = build_person('janis', 'joplin')
print(musician)
```

Visualizing functions

Try running some of these examples on pythontutor.com.

Passing a list to a function

You can pass a list as an argument to a function, and the function can work with the values in the list. Any changes the function makes to the list will affect the original list. You can prevent a function from modifying a list by passing a copy of the list as an argument.

Passing a list as an argument

```
def greet_users(names):
    """Print a simple greeting to everyone."""
    for name in names:
        msg = "Hello, " + name + "!"
        print(msg)

usernames = ['hannah', 'ty', 'margot']
greet_users(usernames)
```

Allowing a function to modify a list

The following example sends a list of models to a function for printing. The original list is emptied, and the second list is filled.

```
def print_models(unprinted, printed):
    """3d print a set of models."""
    while unprinted:
        current_model = unprinted.pop()
        print("Printing " + current_model)
        printed.append(current_model)

# Store some unprinted designs,
#  and print each of them.
unprinted = ['phone case', 'pendant', 'ring']
printed = []
print_models(unprinted, printed)

print("\nUnprinted:", unprinted)
print("Printed:", printed)
```

Preventing a function from modifying a list

The following example is the same as the previous one, except the original list is unchanged after calling print_models().

```
def print_models(unprinted, printed):
    """3d print a set of models."""
    while unprinted:
        current_model = unprinted.pop()
        print("Printing " + current_model)
        printed.append(current_model)

# Store some unprinted designs,
#  and print each of them.
original = ['phone case', 'pendant', 'ring']
printed = []

print_models(original[:], printed)
print("\nOriginal:", original)
print("Printed:", printed)
```

Passing an arbitrary number of arguments

*Sometimes you won't know how many arguments a function will need to accept. Python allows you to collect an arbitrary number of arguments into one parameter using the * operator. A parameter that accepts an arbitrary number of arguments must come last in the function definition.*

*The ** operator allows a parameter to collect an arbitrary number of keyword arguments.*

Collecting an arbitrary number of arguments

```
def make_pizza(size, *toppings):
    """Make a pizza."""
    print("\nMaking a " + size + " pizza.")
    print("Toppings:")
    for topping in toppings:
        print("- " + topping)

# Make three pizzas with different toppings.
make_pizza('small', 'pepperoni')
make_pizza('large', 'bacon bits', 'pineapple')
make_pizza('medium', 'mushrooms', 'peppers',
        'onions', 'extra cheese')
```

Collecting an arbitrary number of keyword arguments

```
def build_profile(first, last, **user_info):
    """Build a user's profile dictionary."""
    # Build a dict with the required keys.
    profile = {'first': first, 'last': last}

    # Add any other keys and values.
    for key, value in user_info.items():
        profile[key] = value

    return profile

# Create two users with different kinds
#   of information.
user_0 = build_profile('albert', 'einstein',
        location='princeton')
user_1 = build_profile('marie', 'curie',
        location='paris', field='chemistry')

print(user_0)
print(user_1)
```

What's the best way to structure a function?

As you can see there are many ways to write and call a function. When you're starting out, aim for something that simply works. As you gain experience you'll develop an understanding of the more subtle advantages of different structures such as positional and keyword arguments, and the various approaches to importing functions. For now if your functions do what you need them to, you're doing well.

Modules

You can store your functions in a separate file called a module, and then import the functions you need into the file containing your main program. This allows for cleaner program files. (Make sure your module is stored in the same directory as your main program.)

Storing a function in a module

File: pizza.py

```
def make_pizza(size, *toppings):
    """Make a pizza."""
    print("\nMaking a " + size + " pizza.")
    print("Toppings:")
    for topping in toppings:
        print("- " + topping)
```

Importing an entire module

File: making_pizzas.py
Every function in the module is available in the program file.

```
import pizza

pizza.make_pizza('medium', 'pepperoni')
pizza.make_pizza('small', 'bacon', 'pineapple')
```

Importing a specific function

Only the imported functions are available in the program file.

```
from pizza import make_pizza

make_pizza('medium', 'pepperoni')
make_pizza('small', 'bacon', 'pineapple')
```

Giving a module an alias

```
import pizza as p

p.make_pizza('medium', 'pepperoni')
p.make_pizza('small', 'bacon', 'pineapple')
```

Giving a function an alias

```
from pizza import make_pizza as mp

mp('medium', 'pepperoni')
mp('small', 'bacon', 'pineapple')
```

Importing all functions from a module

Don't do this, but recognize it when you see it in others' code. It can result in naming conflicts, which can cause errors.

```
from pizza import *

make_pizza('medium', 'pepperoni')
make_pizza('small', 'bacon', 'pineapple')
```

More cheat sheets available at
ehmatthes.github.io/pcc/

Beginner's Python Cheat Sheet - Classes

What are classes?

Classes are the foundation of object-oriented programming. Classes represent real-world things you want to model in your programs: for example dogs, cars, and robots. You use a class to make objects, which are specific instances of dogs, cars, and robots. A class defines the general behavior that a whole category of objects can have, and the information that can be associated with those objects.

Classes can inherit from each other – you can write a class that extends the functionality of an existing class. This allows you to code efficiently for a wide variety of situations.

Creating and using a class

Consider how we might model a car. What information would we associate with a car, and what behavior would it have? The information is stored in variables called attributes, and the behavior is represented by functions. Functions that are part of a class are called methods.

The Car class

```
class Car():
    """A simple attempt to model a car."""

    def __init__(self, make, model, year):
        """Initialize car attributes."""
        self.make = make
        self.model = model
        self.year = year

        # Fuel capacity and level in gallons.
        self.fuel_capacity = 15
        self.fuel_level = 0

    def fill_tank(self):
        """Fill gas tank to capacity."""
        self.fuel_level = self.fuel_capacity
        print("Fuel tank is full.")

    def drive(self):
        """Simulate driving."""
        print("The car is moving.")
```

Creating and using a class (cont.)

Creating an object from a class

```
my_car = Car('audi', 'a4', 2016)
```

Accessing attribute values

```
print(my_car.make)
print(my_car.model)
print(my_car.year)
```

Calling methods

```
my_car.fill_tank()
my_car.drive()
```

Creating multiple objects

```
my_car = Car('audi', 'a4', 2016)
my_old_car = Car('subaru', 'outback', 2013)
my_truck = Car('toyota', 'tacoma', 2010)
```

Modifying attributes

You can modify an attribute's value directly, or you can write methods that manage updating values more carefully.

Modifying an attribute directly

```
my_new_car = Car('audi', 'a4', 2016)
my_new_car.fuel_level = 5
```

Writing a method to update an attribute's value

```
def update_fuel_level(self, new_level):
    """Update the fuel level."""
    if new_level <= self.fuel_capacity:
        self.fuel_level = new_level
    else:
        print("The tank can't hold that much!")
```

Writing a method to increment an attribute's value

```
def add_fuel(self, amount):
    """Add fuel to the tank."""
    if (self.fuel_level + amount
            <= self.fuel_capacity):
        self.fuel_level += amount
        print("Added fuel.")
    else:
        print("The tank won't hold that much.")
```

Naming conventions

In Python class names are written in CamelCase and object names are written in lowercase with underscores. Modules that contain classes should still be named in lowercase with underscores.

Class inheritance

If the class you're writing is a specialized version of another class, you can use inheritance. When one class inherits from another, it automatically takes on all the attributes and methods of the parent class. The child class is free to introduce new attributes and methods, and override attributes and methods of the parent class.

To inherit from another class include the name of the parent class in parentheses when defining the new class.

The __init__() method for a child class

```
class ElectricCar(Car):
    """A simple model of an electric car."""

    def __init__(self, make, model, year):
        """Initialize an electric car."""
        super().__init__(make, model, year)

        # Attributes specific to electric cars.
        # Battery capacity in kWh.
        self.battery_size = 70
        # Charge level in %.
        self.charge_level = 0
```

Adding new methods to the child class

```
class ElectricCar(Car):
    --snip--
    def charge(self):
        """Fully charge the vehicle."""
        self.charge_level = 100
        print("The vehicle is fully charged.")
```

Using child methods and parent methods

```
my_ecar = ElectricCar('tesla', 'model s', 2016)

my_ecar.charge()
my_ecar.drive()
```

Finding your workflow

There are many ways to model real world objects and situations in code, and sometimes that variety can feel overwhelming. Pick an approach and try it – if your first attempt doesn't work, try a different approach.

Class inheritance (cont.)

Overriding parent methods

```
class ElectricCar(Car):
    --snip--
    def fill_tank(self):
        """Display an error message."""
        print("This car has no fuel tank!")
```

Instances as attributes

A class can have objects as attributes. This allows classes to work together to model complex situations.

A Battery class

```
class Battery():
    """A battery for an electric car."""

    def __init__(self, size=70):
        """Initialize battery attributes."""
        # Capacity in kWh, charge level in %.
        self.size = size
        self.charge_level = 0

    def get_range(self):
        """Return the battery's range."""
        if self.size == 70:
            return 240
        elif self.size == 85:
            return 270
```

Using an instance as an attribute

```
class ElectricCar(Car):
    --snip--

    def __init__(self, make, model, year):
        """Initialize an electric car."""
        super().__init__(make, model, year)

        # Attribute specific to electric cars.
        self.battery = Battery()

    def charge(self):
        """Fully charge the vehicle."""
        self.battery.charge_level = 100
        print("The vehicle is fully charged.")
```

Using the instance

```
my_ecar = ElectricCar('tesla', 'model x', 2016)

my_ecar.charge()
print(my_ecar.battery.get_range())
my_ecar.drive()
```

Importing classes

Class files can get long as you add detailed information and functionality. To help keep your program files uncluttered, you can store your classes in modules and import the classes you need into your main program.

Storing classes in a file

car.py

```
"""Represent gas and electric cars."""

class Car():
    """A simple attempt to model a car."""
    --snip—

class Battery():
    """A battery for an electric car."""
    --snip--

class ElectricCar(Car):
    """A simple model of an electric car."""
    --snip--
```

Importing individual classes from a module

my_cars.py

```
from car import Car, ElectricCar

my_beetle = Car('volkswagen', 'beetle', 2016)
my_beetle.fill_tank()
my_beetle.drive()

my_tesla = ElectricCar('tesla', 'model s',
2016)
my_tesla.charge()
my_tesla.drive()
```

Importing an entire module

```
import car

my_beetle = car.Car(
        'volkswagen', 'beetle', 2016)
my_beetle.fill_tank()
my_beetle.drive()

my_tesla = car.ElectricCar(
        'tesla', 'model s', 2016)
my_tesla.charge()
my_tesla.drive()
```

Importing all classes from a module

(Don't do this, but recognize it when you see it.)

```
from car import *

my_beetle = Car('volkswagen', 'beetle', 2016)
```

Classes in Python 2.7

Classes should inherit from object

```
class ClassName(object):
```

The Car class in Python 2.7

```
class Car(object):
```

Child class __init__() method is different

```
class ChildClassName(ParentClass):
    def __init__(self):
        super(ClassName, self).__init__()
```

The ElectricCar class in Python 2.7

```
class ElectricCar(Car):
    def __init__(self, make, model, year):
        super(ElectricCar, self).__init__(
                make, model, year)
```

Storing objects in a list

A list can hold as many items as you want, so you can make a large number of objects from a class and store them in a list.

Here's an example showing how to make a fleet of rental cars, and make sure all the cars are ready to drive.

A fleet of rental cars

```
from car import Car, ElectricCar

# Make lists to hold a fleet of cars.
gas_fleet = []
electric_fleet = []

# Make 500 gas cars and 250 electric cars.
for _ in range(500):
    car = Car('ford', 'focus', 2016)
    gas_fleet.append(car)
for _ in range(250):
    ecar = ElectricCar('nissan', 'leaf', 2016)
    electric_fleet.append(ecar)

# Fill the gas cars, and charge electric cars.
for car in gas_fleet:
    car.fill_tank()
for ecar in electric_fleet:
    ecar.charge()

print("Gas cars:", len(gas_fleet))
print("Electric cars:", len(electric_fleet))
```

More cheat sheets available at
ehmatthes.github.io/pcc/

Beginner's Python Cheat Sheet — Files and Exceptions

What are files? What are exceptions?

Your programs can read information in from files, and they can write data to files. Reading from files allows you to work with a wide variety of information; writing to files allows users to pick up where they left off the next time they run your program. You can write text to files, and you can store Python structures such as lists in data files.

Exceptions are special objects that help your programs respond to errors in appropriate ways. For example if your program tries to open a file that doesn't exist, you can use exceptions to display an informative error message instead of having the program crash.

Reading from a file

To read from a file your program needs to open the file and then read the contents of the file. You can read the entire contents of the file at once, or read the file line by line. The with statement makes sure the file is closed properly when the program has finished accessing the file.

Reading an entire file at once

```
filename = 'siddhartha.txt'

with open(filename) as f_obj:
    contents = f_obj.read()

print(contents)
```

Reading line by line

Each line that's read from the file has a newline character at the end of the line, and the print function adds its own newline character. The rstrip() method gets rid of the the extra blank lines this would result in when printing to the terminal.

```
filename = 'siddhartha.txt'

with open(filename) as f_obj:
    for line in f_obj:
        print(line.rstrip())
```

Reading from a file (cont.)

Storing the lines in a list

```
filename = 'siddhartha.txt'

with open(filename) as f_obj:
    lines = f_obj.readlines()

for line in lines:
    print(line.rstrip())
```

Writing to a file

Passing the 'w' argument to open() tells Python you want to write to the file. Be careful; this will erase the contents of the file if it already exists. Passing the 'a' argument tells Python you want to append to the end of an existing file.

Writing to an empty file

```
filename = 'programming.txt'

with open(filename, 'w') as f:
    f.write("I love programming!")
```

Writing multiple lines to an empty file

```
filename = 'programming.txt'

with open(filename, 'w') as f:
    f.write("I love programming!\n")
    f.write("I love creating new games.\n")
```

Appending to a file

```
filename = 'programming.txt'

with open(filename, 'a') as f:
    f.write("I also love working with data.\n")
    f.write("I love making apps as well.\n")
```

File paths

When Python runs the open() function, it looks for the file in the same directory where the program that's being excuted is stored. You can open a file from a subfolder using a relative path. You can also use an absolute path to open any file on your system.

Opening a file from a subfolder

```
f_path = "text_files/alice.txt"

with open(f_path) as f_obj:
    lines = f_obj.readlines()

for line in lines:
    print(line.rstrip())
```

File paths (cont.)

Opening a file using an absolute path

```
f_path = "/home/ehmatthes/books/alice.txt"

with open(f_path) as f_obj:
    lines = f_obj.readlines()
```

Opening a file on Windows

Windows will sometimes interpret forward slashes incorrectly. If you run into this, use backslashes in your file paths.

```
f_path = "C:\Users\ehmatthes\books\alice.txt"

with open(f_path) as f_obj:
    lines = f_obj.readlines()
```

The try-except block

When you think an error may occur, you can write a try-except block to handle the exception that might be raised. The try block tells Python to try running some code, and the except block tells Python what to do if the code results in a particular kind of error.

Handling the ZeroDivisionError exception

```
try:
    print(5/0)
except ZeroDivisionError:
    print("You can't divide by zero!")
```

Handling the FileNotFoundError exception

```
f_name = 'siddhartha.txt'

try:
    with open(f_name) as f_obj:
        lines = f_obj.readlines()
except FileNotFoundError:
    msg = "Can't find file {0}.".format(f_name)
    print(msg)
```

Knowing which exception to handle

It can be hard to know what kind of exception to handle when writing code. Try writing your code without a try block, and make it generate an error. The traceback will tell you what kind of exception your program needs to handle.

The else block

The try block should only contain code that may cause an error. Any code that depends on the try block running successfully should be placed in the else block.

Using an else block

```
print("Enter two numbers. I'll divide them.")

x = input("First number: ")
y = input("Second number: ")

try:
    result = int(x) / int(y)
except ZeroDivisionError:
    print("You can't divide by zero!")
else:
    print(result)
```

Preventing crashes from user input

Without the except block in the following example, the program would crash if the user tries to divide by zero. As written, it will handle the error gracefully and keep running.

```
"""A simple calculator for division only."""

print("Enter two numbers. I'll divide them.")
print("Enter 'q' to quit.")

while True:
    x = input("\nFirst number: ")
    if x == 'q':
        break
    y = input("Second number: ")
    if y == 'q':
        break

    try:
        result = int(x) / int(y)
    except ZeroDivisionError:
        print("You can't divide by zero!")
    else:
        print(result)
```

Deciding which errors to report

Well-written, properly tested code is not very prone to internal errors such as syntax or logical errors. But every time your program depends on something external such as user input or the existence of a file, there's a possibility of an exception being raised.

It's up to you how to communicate errors to your users. Sometimes users need to know if a file is missing; sometimes it's better to handle the error silently. A little experience will help you know how much to report.

Failing silently

Sometimes you want your program to just continue running when it encounters an error, without reporting the error to the user. Using the pass statement in an else block allows you to do this.

Using the pass statement in an else block

```
f_names = ['alice.txt', 'siddhartha.txt',
        'moby_dick.txt', 'little_women.txt']

for f_name in f_names:
    # Report the length of each file found.
    try:
        with open(f_name) as f_obj:
            lines = f_obj.readlines()
    except FileNotFoundError:
        # Just move on to the next file.
        pass
    else:
        num_lines = len(lines)
        msg = "{0} has {1} lines.".format(
            f_name, num_lines)
        print(msg)
```

Avoid bare except blocks

Exception-handling code should catch specific exceptions that you expect to happen during your program's execution. A bare except block will catch all exceptions, including keyboard interrupts and system exits you might need when forcing a program to close.

If you want to use a try block and you're not sure which exception to catch, use Exception. It will catch most exceptions, but still allow you to interrupt programs intentionally.

Don't use bare except blocks

```
try:
    # Do something
except:
    pass
```

Use Exception instead

```
try:
    # Do something
except Exception:
    pass
```

Printing the exception

```
try:
    # Do something
except Exception as e:
    print(e, type(e))
```

Storing data with json

The json module allows you to dump simple Python data structures into a file, and load the data from that file the next time the program runs. The JSON data format is not specific to Python, so you can share this kind of data with people who work in other languages as well.

Knowing how to manage exceptions is important when working with stored data. You'll usually want to make sure the data you're trying to load exists before working with it.

Using json.dump() to store data

```
"""Store some numbers."""

import json

numbers = [2, 3, 5, 7, 11, 13]

filename = 'numbers.json'
with open(filename, 'w') as f_obj:
    json.dump(numbers, f_obj)
```

Using json.load() to read data

```
"""Load some previously stored numbers."""

import json

filename = 'numbers.json'
with open(filename) as f_obj:
    numbers = json.load(f_obj)

print(numbers)
```

Making sure the stored data exists

```
import json

f_name = 'numbers.json'

try:
    with open(f_name) as f_obj:
        numbers = json.load(f_obj)
except FileNotFoundError:
    msg = "Can't find {0}.".format(f_name)
    print(msg)
else:
    print(numbers)
```

Practice with exceptions

Take a program you've already written that prompts for user input, and add some error-handling code to the program.

More cheat sheets available at
ehmatthes.github.io/pcc/

datacamp python

Working with Dates and Times in Python

Learn Python Basics online at www.DataCamp.com

> Key definitions

When working with dates and times, you will encounter technical terms and jargon such as the following:

- **Date:** Handles dates without time.
- **POSIXct:** Handles date & time in calendar time.
- **POSIXlt:** Handles date & time in local time.
- **Hms:** Parses periods with hour, minute, and second
- **Timestamp:** Represents a single pandas date & time
- **Interval:** Defines an open or closed range between dates and times
- **Time delta:** Computes time difference between different datetimes

> The ISO8601 datetime format

The **ISO 8601 datetime format** specifies datetimes from the largest to the smallest unit of time **(YYYY-MM-DD HH:MM:SS TZ).** Some of the advantages of ISO 8601 are:

- It avoids ambiguities between MM/DD/YYYY and DD/MM/YYYY formats.
- The 4-digit year representation mitigates overflow problems after the year 2099.
- Using numeric month values (08 not AUG) makes it language independent, so dates make sense throughout the world.
- Python is optimized for this format since it makes comparison and sorting easier.

> Packages used in this cheat sheet

Load the packages and dataset used in this cheatsheet.

```
import datetime as dt
import time as tm
import pytz
import pandas as pd
```

In this cheat sheet, we will be using 3 pandas series — `iso, us, non_us,` and 1 pandas DataFrame `parts`

iso
1969-07-20 20:17:40
1969-11-19 06:54:35
1971-02-05 09:18:11

us
07/20/1969 20:17:40
11/19/1969 06:54:35
02/05/1971 09:18:11

non_us
20/07/1969 20:17:40
19/11/1969 06:54:35
05/02/1971 09:18:11

parts		
year	month	day
1969	7	20
1969	11	19
1971	2	5

> Getting the current date and time

```
# Get the current date
dt.date.today()

# Get the current date and time
dt.datetime.now()
```

> Reading date, datetime, and time columns in a CSV file

```
# Specify datetime column
pd.read_csv("filename.csv", parse_dates = ["col1", "col2"])

# Specify datetime column
pd.read_csv("filename.csv", parse_dates = {"col1": ["year", "month", "day"]})
```

> Parsing dates, datetimes, and times

```
# Parse dates in ISO format
pd.to_datetime(iso)

# Parse dates in US format
pd.to_datetime(us, dayfirst=False)

# Parse dates in NON US format
pd.to_datetime(non_us, dayfirst=True)

# Parse dates, guessing a single format
pd.to_datetime(iso, infer_datetime_format=True)

# Parse dates in single, specified format
pd.to_datetime(iso, format="%Y-%m-%d %H:%M:%S")

# Parse dates in single, specified format
pd.to_datetime(us, format="%m/%d/%Y %H:%M:%S")

# Make dates from components
pd.to_datetime(parts)
```

> Extracting components

```
# Parse strings to datetimes
dttm = pd.to_datetime(iso)

# Get year from datetime pandas series
dttm.dt.year

# Get day of the year from datetime pandas series
dttm.dt.day_of_year

# Get month name from datetime pandas series
dttm.dt.month_name()

# Get day name from datetime pandas series
dttm.dt.day_name()

# Get datetime.datetime format from datetime pandas series
dttm.dt.to_pydatetime()
```

> Rounding dates

```
# Rounding dates to nearest time unit
dttm.dt.round('1min')

# Flooring dates to nearest time unit
dttm.dt.floor('1min')

# Ceiling dates to nearest time unit
dttm.dt.ceil('1min')
```

> Arithmetic

```
# Create two datetimes
now = dt.datetime.now()
then = pd.Timestamp('2021-09-15 10:03:30')

# Get time elapsed as timedelta object
now - then

# Get time elapsed in seconds
(now - then).total_seconds()

# Adding a day to a datetime
dt.datetime(2022,8,5,11,13,50) + dt.timedelta(days=1)
```

> Time Zones

```
# Get current time zone
tm.localtime().tm_zone

# Get a list of all time zones
pytz.all_timezones

# Parse strings to datetimes
dttm = pd.to_datetime(iso)

# Get datetime with timezone using location
dttm.dt.tz_localize('CET', ambiguous='infer')

# Get datetime with timezone using UTC offset
dttm.dt.tz_localize('+0100')

# Convert datetime from one timezone to another
dttm.dt.tz_localize('+0100').tz_convert('US/Central')
```

> Time Intervals

```
# Create interval datetimes
start_1 = pd.Timestamp('2021-10-21 03:02:10')
finish_1 = pd.Timestamp('2022-09-15 10:03:30')
start_2 = pd.Timestamp('2022-08-21 03:02:10')
finish_2 = pd.Timestamp('2022-12-15 10:03:30')

# Specify the interval between two datetimes
pd.Interval(start_1, finish_1, closed='right')

# Get the length of an interval
pd.Interval(start_1, finish_1, closed='right').length

# Determine if two intervals are intersecting
pd.Interval(start_1, finish_1,
closed='right').overlaps(pd.Interval(start_2, finish_2, closed='right'))
```

> Time Deltas

```
# Define a timedelta in days
pd.Timedelta(7, "d")

# Convert timedelta to seconds
pd.Timedelta(7, "d").total_seconds()
```

datacamp

python™

Working with text data in Python

Learn Python online at www.DataCamp.com

> Example data used throughout this cheat sheet

Throughout this cheat sheet, we'll be using two pandas series named `suits` and `rock_paper_scissors`.

```
import pandas as pd

suits = pd.Series(["clubs", "Diamonds", "hearts", "Spades"])
rock_paper_scissors = pd.Series(["rock ", " paper", "scissors"])
```

> String lengths and substrings

```
# Get the number of characters with .str.len()
suits.str.len() # Returns 5 8 6 6

# Get substrings by position with .str[]
suits.str[2:5] # Returns "ubs" "amo" "art" "ade"

# Get substrings by negative position with .str[]
suits.str[:-3] # "cl" "Diamo" "hea" "Spa

# Remove whitespace from the start/end with .str.strip()
rock_paper_scissors.str.strip() # "rock" "paper" "scissors"

# Pad strings to a given length with .str.pad()
suits.str.pad(8, fillchar="_") # "___clubs" "Diamonds" "__hearts" "__Spades"
```

> Changing case

```
# Convert to lowercase with .str.lower()
suits.str.lower() # "clubs" "diamonds" "hearts" "spades"

# Convert to uppercase with .str.upper()
suits.str.upper() # "CLUBS" "DIAMONDS" "HEARTS" "SPADES"

# Convert to title case with .str.title()
pd.Series("hello, world!").str.title() # "Hello, World!"

# Convert to sentence case with .str.capitalize()
pd.Series("hello, world!").str.capitalize() # "Hello, world!"
```

> Formatting settings

```
# Generate an example DataFramed named df
df = pd.DataFrame({"x": [0.123, 4.567, 8.901]})
#     x
#  0 0.123
#  1 4.567
#  2 8.901
```

```
# Visualize and format table output
df.style.format(precision = 1)
```

-	x
0	0.1
1	4.5
2	8.9

The output of `style.format` is an `HTML table`

> Splitting strings

```
# Split strings into list of characters with .str.split(pat="")
suits.str.split(pat="")

# [, "c" "l" "u" "b" "s", ]
# [, "D" "i" "a" "m" "o" "n" "d" "s", ]
# [, "h" "e" "a" "r" "t" "s", ]
# [, "S" "p" "a" "d" "e" "s", ]

# Split strings by a separator with .str.split()
suits.str.split(pat = "a")

# ["clubs"]
# ["Di", "monds"]
# ["he", "rts"]
# ["Sp", "des"]

# Split strings and return DataFrame with .str.split(expand=True)
suits.str.split(pat = "a", expand=True)

#        0      1
# 0  clubs   None
# 1     Di  monds
# 2     he    rts
# 3     Sp    des
```

> Joining or concatenating strings

```
# Combine two strings with +
suits + "5" # "clubs5" "Diamonds5" "hearts5" "Spades5"

# Collapse character vector to string with .str.cat()
suits.str.cat(sep=", ") # "clubs, Diamonds, hearts, Spades"

# Duplicate and concatenate strings with *
suits * 2 # "clubsclubs" "DiamondsDiamonds" "heartshearts" "SpadesSpades"
```

> Detecting Matches

```
# Detect if a regex pattern is present in strings with .str.contains()
suits.str.contains("[ae]") # False True True True

# Count the number of matches with .str.count()
suits.str.count("[ae]") # 0 1 2 2

# Locate the position of substrings with str.find()
suits.str.find("e") # -1 -1 1 4
```

> Extracting matches

```
# Extract matches from strings with str.findall()
suits.str.findall(".[ae]") # [] ["ia"] ["he"[ ["pa", "de"]

# Extract capture groups with .str.extractall()
suits.str.extractall("([ae])(.)")
#           0 1
#   match
# 1 0       a m
# 2 0       e a
# 3 0       a d
#   1       e s

# Get subset of strings that match with x[x.str.contains()]
suits[suits.str.contains("d")] # "Diamonds" "Spades"
```

> Replacing matches

```
# Replace a regex match with another string with .str.replace()
suits.str.replace("a", "4") # "clubs" "Di4monds" "he4rts" "Sp4des"

# Remove a suffix with .str.removesuffix()
suits.str.removesuffix # "club" "Diamond" "heart" "Spade"

# Replace a substring with .str.slice_replace()
rhymes = pd.Series(["vein", "gain", "deign"])
rhymes.str.slice_replace(0, 1, "r") # "rein" "rain" "reign"
```

Python For Data Science *Cheat Sheet*

Importing Data

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Importing Data in Python

Most of the time, you'll use either **NumPy** or **pandas** to import your data:

```
>>> import numpy as np
>>> import pandas as pd
```

Help

```
>>> np.info(np.ndarray.dtype)
>>> help(pd.read_csv)
```

Text Files

Plain Text Files

```
>>> filename = 'huck_finn.txt'
>>> file = open(filename, mode='r')
>>> text = file.read()
>>> print(file.closed)
>>> file.close()
>>> print(text)
```

Open the file for reading
Read a file's contents
Check whether file is closed
Close file

Using the context manager `with`

```
>>> with open('huck_finn.txt', 'r') as file:
        print(file.readline())
        print(file.readline())
        print(file.readline())
```

Read a single line

Table Data: Flat Files

Importing Flat Files with numpy

Files with one data type

```
>>> filename = 'mnist.txt'
>>> data = np.loadtxt(filename,
                      delimiter=',',
                      skiprows=2,
                      usecols=[0,2],
                      dtype=str)
```

String used to separate values
Skip the first 2 lines
Read the 1st and 3rd column
The type of the resulting array

Files with mixed data types

```
>>> filename = 'titanic.csv'
>>> data = np.genfromtxt(filename,
                         delimiter=',',
                         names=True,
                         dtype=None)
```

Look for column header

```
>>> data_array = np.recfromcsv(filename)
```

The default `dtype` of the `np.recfromcsv()` function is `None`.

Importing Flat Files with pandas

```
>>> filename = 'winequality-red.csv'
>>> data = pd.read_csv(filename,
                       nrows=5,
                       header=None,
                       sep='\t',
                       comment='#',
                       na_values[""])
```

Number of rows of file to read
Row number to use as col names
Delimiter to use
Character to split comments
String to recognize as NA/NaN

Excel Spreadsheets

```
>>> file = 'urbanpop.xlsx'
>>> data = pd.ExcelFile(file)
>>> df_sheet2 = data.parse('1960-1966',
                           skiprows=[0],
                           names=['Country',
                                  'AAM: War(2002)'])
>>> df_sheet1 = data.parse(0,
                           parse_cols=[0],
                           skiprows=[0],
                           names=['Country'])
```

To access the sheet names, use the `sheet_names` attribute:

```
>>> data.sheet_names
```

SAS Files

```
>>> from sas7bdat import SAS7BDAT
>>> with SAS7BDAT('urbanpop.sas7bdat') as file:
        df_sas = file.to_data_frame()
```

Stata Files

```
>>> data = pd.read_stata('urbanpop.dta')
```

Relational Databases

```
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite://Northwind.sqlite')
```

Use the `table_names()` method to fetch a list of table names:

```
>>> table_names = engine.table_names()
```

Querying Relational Databases

```
>>> con = engine.connect()
>>> rs = con.execute("SELECT * FROM Orders")
>>> df = pd.DataFrame(rs.fetchall())
>>> df.columns = rs.keys()
>>> con.close()
```

Using the context manager `with`

```
>>> with engine.connect() as con:
        rs = con.execute("SELECT OrderID FROM Orders")
        df = pd.DataFrame(rs.fetchmany(size=5))
        df.columns = rs.keys()
```

Querying relational databases with pandas

```
>>> df = pd.read_sql_query("SELECT * FROM Orders", engine)
```

Exploring Your Data

NumPy Arrays

```
>>> data_array.dtype
>>> data_array.shape
>>> len(data_array)
```

Data type of array elements
Array dimensions
Length of array

pandas DataFrames

```
>>> df.head()
>>> df.tail()
>>> df.index
>>> df.columns
>>> df.info()
>>> data_array = data.values
```

Return first DataFrame rows
Return last DataFrame rows
Describe index
Describe DataFrame columns
Info on DataFrame
Convert a DataFrame to an a NumPy array

Pickled Files

```
>>> import pickle
>>> with open('pickled_fruit.pkl', 'rb') as file:
        pickled_data = pickle.load(file)
```

HDF5 Files

```
>>> import h5py
>>> filename = 'H-H1_LOSC_4_v1-815411200-4096.hdf5'
>>> data = h5py.File(filename, 'r')
```

Matlab Files

```
>>> import scipy.io
>>> filename = 'workspace.mat'
>>> mat = scipy.io.loadmat(filename)
```

Exploring Dictionaries

Accessing Elements with Functions

```
>>> print(mat.keys())
>>> for key in data.keys():
        print(key)
meta
quality
strain
>>> pickled_data.values()
>>> print(mat.items())
```

Print dictionary keys
Print dictionary keys

Return dictionary values
Returns items in list format of (key, value) tuple pairs

Accessing Data Items with Keys

```
>>> for key in data ['meta'].keys()
        print(key)
Description
DescriptionURL
Detector
Duration
GPSstart
Observatory
Type
UTCstart
>>> print(data['meta']['Description'].value)
```

Explore the HDF5 structure

Retrieve the value for a key

Navigating Your FileSystem

Magic Commands

```
!ls
%cd ..
%pwd
```

List directory contents of files and directories
Change current working directory
Return the current working directory path

`os` Library

```
>>> import os
>>> path = "/usr/tmp"
>>> wd = os.getcwd()
>>> os.listdir(wd)
>>> os.chdir(path)
>>> os.rename("test1.txt",
              "test2.txt")
>>> os.remove("test1.txt")
>>> os.mkdir("newdir")
```

Store the name of current directory in a string
Output contents of the directory in a list
Change current working directory
Rename a file

Delete an existing file
Create a new directory

Python For Data Science *Cheat Sheet*

NumPy Basics

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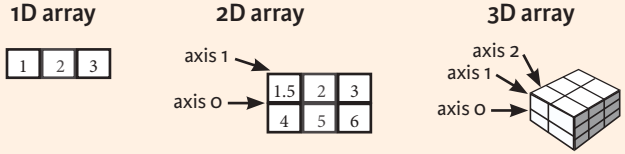
NumPy

The **NumPy** library is the core library for scientific computing in Python. It provides a high-performance multidimensional array object, and tools for working with these arrays.

Use the following import convention:

```
>>> import numpy as np
```

NumPy Arrays



Creating Arrays

```
>>> a = np.array([1,2,3])
>>> b = np.array([(1.5,2,3), (4,5,6)], dtype = float)
>>> c = np.array([[(1.5,2,3), (4,5,6)], [(3,2,1), (4,5,6)]],
                 dtype = float)
```

Initial Placeholders

```
>>> np.zeros((3,4))                  Create an array of zeros
>>> np.ones((2,3,4),dtype=np.int16)  Create an array of ones
>>> d = np.arange(10,25,5)           Create an array of evenly
                                     spaced values (step value)
>>> np.linspace(0,2,9)               Create an array of evenly
                                     spaced values (number of samples)
>>> e = np.full((2,2),7)             Create a constant array
>>> f = np.eye(2)                    Create a 2X2 identity matrix
>>> np.random.random((2,2))          Create an array with random values
>>> np.empty((3,2))                  Create an empty array
```

I/O

Saving & Loading On Disk

```
>>> np.save('my_array', a)
>>> np.savez('array.npz', a, b)
>>> np.load('my_array.npy')
```

Saving & Loading Text Files

```
>>> np.loadtxt("myfile.txt")
>>> np.genfromtxt("my_file.csv", delimiter=',')
>>> np.savetxt("myarray.txt", a, delimiter=" ")
```

Data Types

```
>>> np.int64       Signed 64-bit integer types
>>> np.float32     Standard double-precision floating point
>>> np.complex     Complex numbers represented by 128 floats
>>> np.bool        Boolean type storing TRUE and FALSE values
>>> np.object      Python object type
>>> np.string_     Fixed-length string type
>>> np.unicode_    Fixed-length unicode type
```

Inspecting Your Array

```
>>> a.shape          Array dimensions
>>> len(a)           Length of array
>>> b.ndim           Number of array dimensions
>>> e.size           Number of array elements
>>> b.dtype          Data type of array elements
>>> b.dtype.name     Name of data type
>>> b.astype(int)    Convert an array to a different type
```

Asking For Help

```
>>> np.info(np.ndarray.dtype)
```

Array Mathematics

Arithmetic Operations

```
>>> g = a - b                        Subtraction
  array([[-0.5,  0. ,  0. ],
         [-3. , -3. , -3. ]])
>>> np.subtract(a,b)                 Subtraction
>>> b + a                            Addition
  array([[ 2.5,  4. ,  6. ],
         [ 5. ,  7. ,  9. ]])
>>> np.add(b,a)                      Addition
>>> a / b                            Division
  array([[ 0.66666667,  1.        ,  1.        ],
         [ 0.25      ,  0.4       ,  0.5       ]])
>>> np.divide(a,b)                   Division
>>> a * b                            Multiplication
  array([[  1.5,   4. ,   9. ],
         [  4. ,  10. ,  18. ]])
>>> np.multiply(a,b)                 Multiplication
>>> np.exp(b)                        Exponentiation
>>> np.sqrt(b)                       Square root
>>> np.sin(a)                        Print sines of an array
>>> np.cos(b)                        Element-wise cosine
>>> np.log(a)                        Element-wise natural logarithm
>>> e.dot(f)                         Dot product
  array([[ 7.,  7.],
         [ 7.,  7.]])
```

Comparison

```
>>> a == b                           Element-wise comparison
  array([[False,  True,  True],
         [False, False, False]], dtype=bool)
>>> a < 2                            Element-wise comparison
  array([True, False, False], dtype=bool)
>>> np.array_equal(a, b)             Array-wise comparison
```

Aggregate Functions

```
>>> a.sum()                          Array-wise sum
>>> a.min()                          Array-wise minimum value
>>> b.max(axis=0)                    Maximum value of an array row
>>> b.cumsum(axis=1)                 Cumulative sum of the elements
>>> a.mean()                         Mean
>>> b.median()                       Median
>>> a.corrcoef()                     Correlation coefficient
>>> np.std(b)                        Standard deviation
```

Copying Arrays

```
>>> h = a.view()                     Create a view of the array with the same data
>>> np.copy(a)                       Create a copy of the array
>>> h = a.copy()                     Create a deep copy of the array
```

Sorting Arrays

```
>>> a.sort()                         Sort an array
>>> c.sort(axis=0)                   Sort the elements of an array's axis
```

Subsetting, Slicing, Indexing

Also see Lists

Subsetting

```
>>> a[2]                             Select the element at the 2nd index
  3
>>> b[1,2]                           Select the element at row 0 column 2
  6.0                                (equivalent to b[1][2])
```

Slicing

```
>>> a[0:2]                           Select items at index 0 and 1
  array([1, 2])
>>> b[0:2,1]                         Select items at rows 0 and 1 in column 1
  array([ 2.,  5.])
>>> b[:1]                            Select all items at row 0
  array([[1.5, 2., 3.]])             (equivalent to b[0:1, :])
>>> c[1,...]                         Same as [1,:,:]
  array([[[ 3.,  2.,  1.],
          [ 4.,  5.,  6.]]])
>>> a[ : :-1]                        Reversed array a
  array([3, 2, 1])
```

Boolean Indexing

```
>>> a[a<2]                           Select elements from a less than 2
  array([1])
```

Fancy Indexing

```
>>> b[[1, 0, 1, 0],[0, 1, 2, 0]]    Select elements (1,0),(0,1),(1,2) and (0,0)
  array([ 4. , 2. , 6. , 1.5])
>>> b[[1, 0, 1, 0]][:,[0,1,2,0]]    Select a subset of the matrix's rows
  array([[ 4. ,  5. ,  6. ,  4. ],   and columns
         [ 1.5,  2. ,  3. ,  1.5],
         [ 4. ,  5. ,  6. ,  4. ],
         [ 1.5,  2. ,  3. ,  1.5]])
```

Array Manipulation

Transposing Array

```
>>> i = np.transpose(b)              Permute array dimensions
>>> i.T                              Permute array dimensions
```

Changing Array Shape

```
>>> b.ravel()                        Flatten the array
>>> g.reshape(3,-2)                  Reshape, but don't change data
```

Adding/Removing Elements

```
>>> h.resize((2,6))                  Return a new array with shape (2,6)
>>> np.append(h,g)                   Append items to an array
>>> np.insert(a, 1, 5)               Insert items in an array
>>> np.delete(a,[1])                 Delete items from an array
```

Combining Arrays

```
>>> np.concatenate((a,d),axis=0)     Concatenate arrays
  array([ 1,  2,  3, 10, 15, 20])
>>> np.vstack((a,b))                 Stack arrays vertically (row-wise)
  array([[ 1. ,  2. ,  3. ],
         [ 1.5,  2. ,  3. ],
         [ 4. ,  5. ,  6. ]])
>>> np.r_[e,f]                       Stack arrays vertically (row-wise)
>>> np.hstack((e,f))                 Stack arrays horizontally (column-wise)
  array([[ 7.,  7.,  1.,  0.],
         [ 7.,  7.,  0.,  1.]])
>>> np.column_stack((a,d))           Create stacked column-wise arrays
  array([[ 1, 10],
         [ 2, 15],
         [ 3, 20]])
>>> np.c_[a,d]                       Create stacked column-wise arrays
```

Splitting Arrays

```
>>> np.hsplit(a,3)                   Split the array horizontally at the 3rd
  [array([1]),array([2]),array([3])]  index
>>> np.vsplit(c,2)                   Split the array vertically at the 2nd index
[array([[[ 1.5,  2. ,  1. ],
         [ 4. ,  5. ,  6. ]]]),
 array([[[ 3.,  2.,  3.],
         [ 4.,  5.,  6.]]])]
```

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Pandas Basics

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Pandas

The **Pandas** library is built on NumPy and provides easy-to-use **data structures** and **data analysis** tools for the Python programming language.

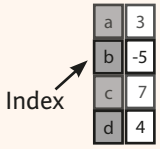
Use the following import convention:

```
>>> import pandas as pd
```

Pandas Data Structures

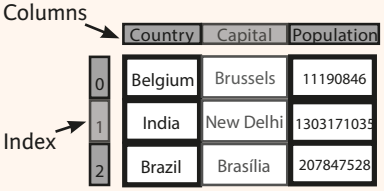
Series

A **one-dimensional** labeled array capable of holding any data type




```
>>> s = pd.Series([3, -5, 7, 4], index=['a', 'b', 'c', 'd'])
```

DataFrame



A **two-dimensional** labeled data structure with columns of potentially different types

```
>>> data = {'Country': ['Belgium', 'India', 'Brazil'],
            'Capital': ['Brussels', 'New Delhi', 'Brasília'],
            'Population': [11190846, 1303171035, 207847528]}

>>> df = pd.DataFrame(data,
                      columns=['Country', 'Capital', 'Population'])
```

Asking For Help

```
>>> help(pd.Series.loc)
```

Selection

Also see NumPy Arrays

Getting

```
>>> s['b']
 -5

>>> df[1:]
   Country     Capital   Population
 1   India   New Delhi   1303171035
 2  Brazil    Brasília    207847528
```

Get one element

Get subset of a DataFrame

Selecting, Boolean Indexing & Setting

By Position

```
>>> df.iloc[[0],[0]]
 'Belgium'
>>> df.iat([0],[0])
 'Belgium'
```

Select single value by row & column

By Label

```
>>> df.loc[[0], ['Country']]
 'Belgium'
>>> df.at([0], ['Country'])
 'Belgium'
```

Select single value by row & column labels

By Label/Position

```
>>> df.ix[2]
 Country      Brazil
 Capital    Brasília
 Population  207847528
```

Select single row of subset of rows

```
>>> df.ix[:,'Capital']
 0     Brussels
 1    New Delhi
 2     Brasília
```

Select a single column of subset of columns

```
>>> df.ix[1,'Capital']
 'New Delhi'
```

Select rows and columns

Boolean Indexing

```
>>> s[~(s > 1)]
>>> s[(s < -1) | (s > 2)]
>>> df[df['Population']>1200000000]
```

Series `s` where value is not >1
`s` where value is <-1 or >2
Use filter to adjust DataFrame

Setting

```
>>> s['a'] = 6
```

Set index `a` of Series `s` to 6

Dropping

```
>>> s.drop(['a', 'c'])
>>> df.drop('Country', axis=1)
```

Drop values from rows (axis=0)
Drop values from columns(axis=1)

Sort & Rank

```
>>> df.sort_index()
>>> df.sort_values(by='Country')
>>> df.rank()
```

Sort by labels along an axis
Sort by the values along an axis
Assign ranks to entries

Retrieving Series/DataFrame Information

Basic Information

```
>>> df.shape
>>> df.index
>>> df.columns
>>> df.info()
>>> df.count()
```

(rows,columns)
Describe index
Describe DataFrame columns
Info on DataFrame
Number of non-NA values

Summary

```
>>> df.sum()
>>> df.cumsum()
>>> df.min()/df.max()
>>> df.idxmin()/df.idxmax()
>>> df.describe()
>>> df.mean()
>>> df.median()
```

Sum of values
Cummulative sum of values
Minimum/maximum values
Minimum/Maximum index value
Summary statistics
Mean of values
Median of values

Applying Functions

```
>>> f = lambda x: x*2
>>> df.apply(f)
>>> df.applymap(f)
```

Apply function
Apply function element-wise

Data Alignment

Internal Data Alignment

NA values are introduced in the indices that don't overlap:

```
>>> s3 = pd.Series([7, -2, 3], index=['a', 'c', 'd'])
>>> s + s3
  a     10.0
  b      NaN
  c      5.0
  d      7.0
```

Arithmetic Operations with Fill Methods

You can also do the internal data alignment yourself with the help of the fill methods:

```
>>> s.add(s3, fill_value=0)
  a    10.0
  b    -5.0
  c    5.0
  d    7.0
>>> s.sub(s3, fill_value=2)
>>> s.div(s3, fill_value=4)
>>> s.mul(s3, fill_value=3)
```

I/O

Read and Write to CSV

```
>>> pd.read_csv('file.csv', header=None, nrows=5)
>>> df.to_csv('myDataFrame.csv')
```

Read and Write to Excel

```
>>> pd.read_excel('file.xlsx')
>>> df.to_excel('dir/myDataFrame.xlsx', sheet_name='Sheet1')
```

Read multiple sheets from the same file

```
>>> xlsx = pd.ExcelFile('file.xls')
>>> df = pd.read_excel(xlsx, 'Sheet1')
```

Read and Write to SQL Query or Database Table

```
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite:///:memory:')
>>> pd.read_sql("SELECT * FROM my_table;", engine)
>>> pd.read_sql_table('my_table', engine)
>>> pd.read_sql_query("SELECT * FROM my_table;", engine)
```

`read_sql()` is a convenience wrapper around `read_sql_table()` and `read_sql_query()`

```
>>> df.to_sql('myDf', engine)
```

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Pandas

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Reshaping Data

Pivot

```
>>> df3= df2.pivot(index='Date',
                   columns='Type',
                   values='Value')
```

Spread rows into columns

	Date	Type	Value
0	2016-03-01	a	11.432
1	2016-03-02	b	13.031
2	2016-03-01	c	20.784
3	2016-03-03	a	99.906
4	2016-03-02	a	1.303
5	2016-03-03	c	20.784

Type	a	b	c
Date			
2016-03-01	11.432	NaN	20.784
2016-03-02	1.303	13.031	NaN
2016-03-03	99.906	NaN	20.784

Pivot Table

```
>>> df4 = pd.pivot_table(df2,
                         values='Value',
                         index='Date',
                         columns='Type'])
```

Spread rows into columns

Stack / Unstack

```
>>> stacked = df5.stack()
>>> stacked.unstack()
```

Pivot a level of column labels
Pivot a level of index labels

		0	1
1	5	0.233482	0.390959
2	4	0.184713	0.237102
3	3	0.433522	0.429401

Unstacked

1	5	0	0.233482
		1	0.390959
2	4	0	0.184713
		1	0.237102
3	3	0	0.433522
		1	0.429401

Stacked

Melt

```
>>> pd.melt(df2,
            id_vars=["Date"],
            value_vars=["Type", "Value"],
            value_name="Observations")
```

Gather columns into rows

	Date	Type	Value
0	2016-03-01	a	11.432
1	2016-03-02	b	13.031
2	2016-03-01	c	20.784
3	2016-03-03	a	99.906
4	2016-03-02	a	1.303
5	2016-03-03	c	20.784

	Date	Variable	Observations
0	2016-03-01	Type	a
1	2016-03-02	Type	b
2	2016-03-01	Type	c
3	2016-03-03	Type	a
4	2016-03-02	Type	a
5	2016-03-03	Type	c
6	2016-03-01	Value	11.432
7	2016-03-02	Value	13.031
8	2016-03-01	Value	20.784
9	2016-03-03	Value	99.906
10	2016-03-02	Value	1.303
11	2016-03-03	Value	20.784

Iteration

```
>>> df.iteritems()
>>> df.iterrows()
```

(Column-index, Series) pairs
(Row-index, Series) pairs

Advanced Indexing

Also see NumPy Arrays

Selecting

```
>>> df3.loc[:,(df3>1).any()]
>>> df3.loc[:,(df3>1).all()]
>>> df3.loc[:,df3.isnull().any()]
>>> df3.loc[:,df3.notnull().all()]
```

Select cols with any vals >1
Select cols with vals > 1
Select cols with NaN
Select cols without NaN

Indexing With isin

```
>>> df[(df.Country.isin(df2.Type))]
>>> df3.filter(items="a","b"])
>>> df.select(lambda x: not x%5)
```

Find same elements
Filter on values
Select specific elements

Where

```
>>> s.where(s > 0)
```

Subset the data

Query

```
>>> df6.query('second > first')
```

Query DataFrame

Setting/Resetting Index

```
>>> df.set_index('Country')
>>> df4 = df.reset_index()
>>> df = df.rename(index=str,
                   columns={"Country":"cntry",
                            "Capital":"cptl",
                            "Population":"ppltn"})
```

Set the index
Reset the index
Rename DataFrame

Reindexing

```
>>> s2 = s.reindex(['a','c','d','e','b'])
```

Forward Filling

```
>>> df.reindex(range(4),
               method='ffill')
```

	Country	Capital	Population
0	Belgium	Brussels	11190846
1	India	New Delhi	1303171035
2	Brazil	Brasília	207847528
3	Brazil	Brasília	207847528

Backward Filling

```
>>> s3 = s.reindex(range(5),
                   method='bfill')
```

0	3
1	3
2	3
3	3
4	3

MultiIndexing

```
>>> arrays = [np.array([1,2,3]),
              np.array([5,4,3])]
>>> df5 = pd.DataFrame(np.random.rand(3, 2), index=arrays)
>>> tuples = list(zip(*arrays))
>>> index = pd.MultiIndex.from_tuples(tuples,
                                      names=['first', 'second'])
>>> df6 = pd.DataFrame(np.random.rand(3, 2), index=index)
>>> df2.set_index(["Date", "Type"])
```

Duplicate Data

```
>>> s3.unique()
>>> df2.duplicated('Type')
>>> df2.drop_duplicates('Type', keep='last')
>>> df.index.duplicated()
```

Return unique values
Check duplicates
Drop duplicates
Check index duplicates

Grouping Data

Aggregation

```
>>> df2.groupby(by=['Date','Type']).mean()
>>> df4.groupby(level=0).sum()
>>> df4.groupby(level=0).agg({'a':lambda x:sum(x)/len(x),
                              'b': np.sum})
```

Transformation

```
>>> customSum = lambda x: (x+x%2)
>>> df4.groupby(level=0).transform(customSum)
```

Missing Data

```
>>> df.dropna()
>>> df3.fillna(df3.mean())
>>> df2.replace("a", "f")
```

Drop NaN values
Fill NaN values with a predetermined value
Replace values with others

Combining Data

data1

	X1	X2
a	11.432
b	1.303
c	99.906

data2

	X1	X3
a	20.784
b	NaN
d	20.784

Merge

```
>>> pd.merge(data1,
             data2,
             how='left',
             on='X1')
```

	X1	X2	X3
a	11.432	20.784
b	1.303	NaN
c	99.906	NaN

```
>>> pd.merge(data1,
             data2,
             how='right',
             on='X1')
```

	X1	X2	X3
a	11.432	20.784
b	1.303	NaN
d	NaN	20.784

```
>>> pd.merge(data1,
             data2,
             how='inner',
             on='X1')
```

	X1	X2	X3
a	11.432	20.784
b	1.303	NaN

```
>>> pd.merge(data1,
             data2,
             how='outer',
             on='X1')
```

	X1	X2	X3
a	11.432	20.784
b	1.303	NaN
c	99.906	NaN
d	NaN	20.784

Join

```
>>> data1.join(data2, how='right')
```

Concatenate

Vertical

```
>>> s.append(s2)
```

Horizontal/Vertical

```
>>> pd.concat([s,s2],axis=1, keys=['One','Two'])
>>> pd.concat([data1, data2], axis=1, join='inner')
```

Dates

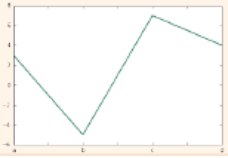
```
>>> df2['Date']= pd.to_datetime(df2['Date'])
>>> df2['Date']= pd.date_range('2000-1-1',
                               periods=6,
                               freq='M')
>>> dates = [datetime(2012,5,1), datetime(2012,5,2)]
>>> index = pd.DatetimeIndex(dates)
>>> index = pd.date_range(datetime(2012,2,1), end, freq='BM')
```

Visualization

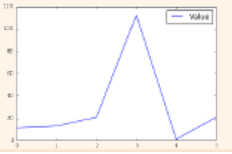
Also see Matplotlib

```
>>> import matplotlib.pyplot as plt
```

```
>>> s.plot()
>>> plt.show()
```



```
>>> df2.plot()
>>> plt.show()
```



Python For Data Science *Cheat Sheet*

Matplotlib

Learn Python Interactively at www.DataCamp.com

Matplotlib

Matplotlib is a Python 2D plotting library which produces publication-quality figures in a variety of hardcopy formats and interactive environments across platforms.

matplotlib

1 Prepare The Data

Also see Lists & NumPy

1D Data

```
>>> import numpy as np
>>> x = np.linspace(0, 10, 100)
>>> y = np.cos(x)
>>> z = np.sin(x)
```

2D Data or Images

```
>>> data = 2 * np.random.random((10, 10))
>>> data2 = 3 * np.random.random((10, 10))
>>> Y, X = np.mgrid[-3:3:100j, -3:3:100j]
>>> U = -1 - X**2 + Y
>>> V = 1 + X - Y**2
>>> from matplotlib.cbook import get_sample_data
>>> img = np.load(get_sample_data('axes_grid/bivariate_normal.npy'))
```

2 Create Plot

```
>>> import matplotlib.pyplot as plt
```

Figure

```
>>> fig = plt.figure()
>>> fig2 = plt.figure(figsize=plt.figaspect(2.0))
```

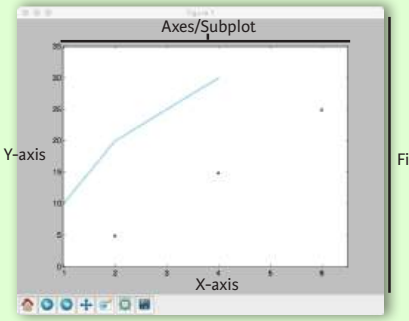
Axes

All plotting is done with respect to an `Axes`. In most cases, a subplot will fit your needs. A subplot is an axes on a grid system.

```
>>> fig.add_axes()
>>> ax1 = fig.add_subplot(221) # row-col-num
>>> ax3 = fig.add_subplot(212)
>>> fig3, axes = plt.subplots(nrows=2,ncols=2)
>>> fig4, axes2 = plt.subplots(ncols=3)
```

Plot Anatomy & Workflow

Plot Anatomy



Workflow

The basic steps to creating plots with matplotlib are:

1 Prepare data 2 Create plot 3 Plot 4 Customize plot 5 Save plot 6 Show plot

```
>>> import matplotlib.pyplot as plt
>>> x = [1,2,3,4]                          Step 1
>>> y = [10,20,25,30]
>>> fig = plt.figure()                     Step 2
>>> ax = fig.add_subplot(111)              Step 3
>>> ax.plot(x, y, color='lightblue', linewidth=3)   Step 3, 4
>>> ax.scatter([2,4,6],
               [5,15,25],
               color='darkgreen',
               marker='^')
>>> ax.set_xlim(1, 6.5)
>>> plt.savefig('foo.png')
>>> plt.show()                             Step 6
```

4 Customize Plot

Colors, Color Bars & Color Maps

```
>>> plt.plot(x, x, x, x**2, x, x**3)
>>> ax.plot(x, y, alpha = 0.4)
>>> ax.plot(x, y, c='k')
>>> fig.colorbar(im, orientation='horizontal')
>>> im = ax.imshow(img,
                   cmap='seismic')
```

Markers

```
>>> fig, ax = plt.subplots()
>>> ax.scatter(x,y,marker=".")
>>> ax.plot(x,y,marker="o")
```

Linestyles

```
>>> plt.plot(x,y,linewidth=4.0)
>>> plt.plot(x,y,ls='solid')
>>> plt.plot(x,y,ls='--')
>>> plt.plot(x,y,'--',x**2,y**2,'-.')
>>> plt.setp(lines,color='r',linewidth=4.0)
```

Text & Annotations

```
>>> ax.text(1,
            -2.1,
            'Example Graph',
            style='italic')
>>> ax.annotate("Sine",
                xy=(8, 0),
                xycoords='data',
                xytext=(10.5, 0),
                textcoords='data',
                arrowprops=dict(arrowstyle="->",
                                connectionstyle="arc3"),)
```

Mathtext

```
>>> plt.title(r'$sigma_i=15$', fontsize=20)
```

Limits, Legends & Layouts

Limits & Autoscaling

```
>>> ax.margins(x=0.0,y=0.1)                  Add padding to a plot
>>> ax.axis('equal')                         Set the aspect ratio of the plot to 1
>>> ax.set(xlim=[0,10.5],ylim=[-1.5,1.5])    Set limits for x-and y-axis
>>> ax.set_xlim(0,10.5)                      Set limits for x-axis
```

Legends

```
>>> ax.set(title='An Example Axes',          Set a title and x-and y-axis labels
           ylabel='Y-Axis',
           xlabel='X-Axis')
>>> ax.legend(loc='best')                    No overlapping plot elements
```

Ticks

```
>>> ax.xaxis.set(ticks=range(1,5),           Manually set x-ticks
                 ticklabels=[3,100,-12,"foo"])
>>> ax.tick_params(axis='y',                 Make y-ticks longer and go in and out
                   direction='inout',
                   length=10)
```

Subplot Spacing

```
>>> fig3.subplots_adjust(wspace=0.5,         Adjust the spacing between subplots
                         hspace=0.3,
                         left=0.125,
                         right=0.9,
                         top=0.9,
                         bottom=0.1)
>>> fig.tight_layout()                       Fit subplot(s) in to the figure area
```

Axis Spines

```
>>> ax1.spines['top'].set_visible(False)     Make the top axis line for a plot invisible
>>> ax1.spines['bottom'].set_position(('outward',10))   Move the bottom axis line outward
```

3 Plotting Routines

1D Data

```
>>> fig, ax = plt.subplots()
>>> lines = ax.plot(x,y)                     Draw points with lines or markers connecting them
>>> ax.scatter(x,y)                          Draw unconnected points, scaled or colored
>>> axes[0,0].bar([1,2,3],[3,4,5])           Plot vertical rectangles (constant width)
>>> axes[1,0].barh([0.5,1,2.5],[0,1,2])      Plot horiontal rectangles (constant height)
>>> axes[1,1].axhline(0.45)                  Draw a horizontal line across axes
>>> axes[0,1].axvline(0.65)                  Draw a vertical line across axes
>>> ax.fill(x,y,color='blue')                Draw filled polygons
>>> ax.fill_between(x,y,color='yellow')      Fill between y-values and o
```

Vector Fields

```
>>> axes[0,1].arrow(0,0,0.5,0.5)             Add an arrow to the axes
>>> axes[1,1].quiver(y,z)                    Plot a 2D field of arrows
>>> axes[0,1].streamplot(X,Y,U,V)            Plot a 2D field of arrows
```

Data Distributions

```
>>> ax1.hist(y)                              Plot a histogram
>>> ax3.boxplot(y)                           Make a box and whisker plot
>>> ax3.violinplot(z)                        Make a violin plot
```

2D Data or Images

```
>>> fig, ax = plt.subplots()
>>> im = ax.imshow(img,                      Colormapped or RGB arrays
                   cmap='gist_earth',
                   interpolation='nearest',
                   vmin=-2,
                   vmax=2)
```

```
>>> axes2[0].pcolor(data2)                   Pseudocolor plot of 2D array
>>> axes2[0].pcolormesh(data)                Pseudocolor plot of 2D array
>>> CS = plt.contour(Y,X,U)                  Plot contours
>>> axes2[2].contourf(data1)                 Plot filled contours
>>> axes2[2]= ax.clabel(CS)                  Label a contour plot
```

5 Save Plot

Save figures

```
>>> plt.savefig('foo.png')
```

Save transparent figures

```
>>> plt.savefig('foo.png', transparent=True)
```

6 Show Plot

```
>>> plt.show()
```

Close & Clear

```
>>> plt.cla()                                Clear an axis
>>> plt.clf()                                Clear the entire figure
>>> plt.close()                              Close a window
```

Beginner's Python Cheat Sheet — matplotlib

What is matplotlib?

Data visualization involves exploring data through visual representations. The matplotlib package helps you make visually appealing representations of the data you're working with. matplotlib is extremely flexible; these examples will help you get started with a few simple visualizations.

Installing matplotlib

matplotlib runs on all systems, but setup is slightly different depending on your OS. If the minimal instructions here don't work for you, see the more detailed instructions at http://ehmatthes.github.io/pcc/. You should also consider installing the Anaconda distrubution of Python from https://continuum.io/downloads/, which includes matplotlib.

matplotlib on Linux

```
$ sudo apt-get install python3-matplotlib
```

matplotlib on OS X

Start a terminal session and enter `import matplotlib` *to see if it's already installed on your system. If not, try this command:*

```
$ pip install --user matplotlib
```

matplotlib on Windows

You first need to install Visual Studio, which you can do from https://dev.windows.com/. The Community edition is free. Then go to https://pypi.python.org/pypi/matplotlib/ or http://www.lfd.uic.edu/~gohlke/pythonlibs/#matplotlib and download an appropriate installer file.

Line graphs and scatter plots

Making a line graph

```
import matplotlib.pyplot as plt

x_values = [0, 1, 2, 3, 4, 5]
squares = [0, 1, 4, 9, 16, 25]
plt.plot(x_values, squares)
plt.show()
```

Line graphs and scatter plots (cont.)

Making a scatter plot

The scatter() function takes a list of x values and a list of y values, and a variety of optional arguments. The `s=10` *argument controls the size of each point.*

```
import matplotlib.pyplot as plt

x_values = list(range(1000))
squares = [x**2 for x in x_values]

plt.scatter(x_values, squares, s=10)
plt.show()
```

Customizing plots

Plots can be customized in a wide variety of ways. Just about any element of a plot can be customized.

Adding titles and labels, and scaling axes

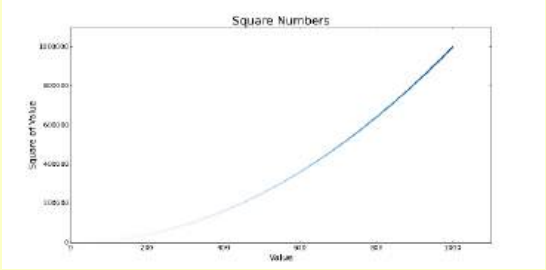
```
import matplotlib.pyplot as plt

x_values = list(range(1000))
squares = [x**2 for x in x_values]
plt.scatter(x_values, squares, s=10)

plt.title("Square Numbers", fontsize=24)
plt.xlabel("Value", fontsize=18)
plt.ylabel("Square of Value", fontsize=18)
plt.tick_params(axis='both', which='major',
                labelsize=14)
plt.axis([0, 1100, 0, 1100000])

plt.show()
```

Using a colormap

A colormap varies the point colors from one shade to another, based on a certain value for each point. The value used to determine the color of each point is passed to the `c` *argument, and the* `cmap` *argument specifies which colormap to use.*

The `edgecolor='none'` *argument removes the black outline from each point.*

```
plt.scatter(x_values, squares, c=squares,
        cmap=plt.cm.Blues, edgecolor='none',
        s=10)
```



Customizing plots (cont.)

Emphasizing points

You can plot as much data as you want on one plot. Here we re-plot the first and last points larger to emphasize them.

```
import matplotlib.pyplot as plt

x_values = list(range(1000))
squares = [x**2 for x in x_values]
plt.scatter(x_values, squares, c=squares,
        cmap=plt.cm.Blues, edgecolor='none',
        s=10)

plt.scatter(x_values[0], squares[0], c='green',
        edgecolor='none', s=100)
plt.scatter(x_values[-1], squares[-1], c='red',
        edgecolor='none', s=100)

plt.title("Square Numbers", fontsize=24)
--snip--
```

Removing axes

You can customize or remove axes entirely. Here's how to access each axis, and hide it.

```
plt.axes().get_xaxis().set_visible(False)
plt.axes().get_yaxis().set_visible(False)
```

Setting a custom figure size

You can make your plot as big or small as you want. Before plotting your data, add the following code. The `dpi` *argument is optional; if you don't know your system's resolution you can omit the argument and adjust the* `figsize` *argument accordingly.*

```
plt.figure(dpi=128, figsize=(10, 6))
```

Saving a plot

The matplotlib viewer has an interactive save button, but you can also save your visualizations programmatically. To do so, replace `plt.show()` *with* `plt.savefig()`*. The* `bbox_inches='tight'` *argument trims extra whitespace from the plot.*

```
plt.savefig('squares.png', bbox_inches='tight')
```

Online resources

The matplotlib gallery and documentation are at http://matplotlib.org/. Be sure to visit the examples, gallery, and pyplot links.

Multiple plots

You can make as many plots as you want on one figure. When you make multiple plots, you can emphasize relationships in the data. For example you can fill the space between two sets of data.

Plotting two sets of data

Here we use `plt.scatter()` twice to plot square numbers and cubes on the same figure.

```
import matplotlib.pyplot as plt

x_values = list(range(11))
squares = [x**2 for x in x_values]
cubes = [x**3 for x in x_values]

plt.scatter(x_values, squares, c='blue',
        edgecolor='none', s=20)
plt.scatter(x_values, cubes, c='red',
        edgecolor='none', s=20)

plt.axis([0, 11, 0, 1100])
plt.show()
```

Filling the space between data sets

The `fill_between()` method fills the space between two data sets. It takes a series of x-values and two series of y-values. It also takes a `facecolor` to use for the fill, and an optional `alpha` argument that controls the color's transparency.

```
plt.fill_between(x_values, cubes, squares,
        facecolor='blue', alpha=0.25)
```

Working with dates and times

Many interesting data sets have a date or time as the x-value. Python's datetime module helps you work with this kind of data.

Generating the current date

The `datetime.now()` function returns a datetime object representing the current date and time.

```
from datetime import datetime as dt

today = dt.now()
date_string = dt.strftime(today, '%m/%d/%Y')
print(date_string)
```

Generating a specific date

You can also generate a datetime object for any date and time you want. The positional order of arguments is year, month, and day. The hour, minute, second, and microsecond arguments are optional.

```
from datetime import datetime as dt

new_years = dt(2017, 1, 1)
fall_equinox = dt(year=2016, month=9, day=22)
```

Working with dates and times (cont.)

Datetime formatting arguments

The `strftime()` function generates a formatted string from a datetime object, and the `strptime()` function genereates a datetime object from a string. The following codes let you work with dates exactly as you need to.

```
%A    Weekday name, such as Monday
%B    Month name, such as January
%m    Month, as a number (01 to 12)
%d    Day of the month, as a number (01 to 31)
%Y    Four-digit year, such as 2016
%y    Two-digit year, such as 16
%H    Hour, in 24-hour format (00 to 23)
%I    Hour, in 12-hour format (01 to 12)
%p    AM or PM
%M    Minutes (00 to 59)
%S    Seconds (00 to 61)
```

Converting a string to a datetime object

```
new_years = dt.strptime('1/1/2017', '%m/%d/%Y')
```

Converting a datetime object to a string

```
ny_string = dt.strftime(new_years, '%B %d, %Y')
print(ny_string)
```

Plotting high temperatures

The following code creates a list of dates and a corresponding list of high temperatures. It then plots the high temperatures, with the date labels displayed in a specific format.

```
from datetime import datetime as dt

import matplotlib.pyplot as plt
from matplotlib import dates as mdates

dates = [
    dt(2016, 6, 21), dt(2016, 6, 22),
    dt(2016, 6, 23), dt(2016, 6, 24),
    ]

highs = [57, 68, 64, 59]

fig = plt.figure(dpi=128, figsize=(10,6))
plt.plot(dates, highs, c='red')
plt.title("Daily High Temps", fontsize=24)
plt.ylabel("Temp (F)", fontsize=16)

x_axis = plt.axes().get_xaxis()
x_axis.set_major_formatter(
        mdates.DateFormatter('%B %d %Y')
        )
fig.autofmt_xdate()

plt.show()
```

Multiple plots in one figure

You can include as many individual graphs in one figure as you want. This is useful, for example, when comparing related datasets.

Sharing an x-axis

The following code plots a set of squares and a set of cubes on two separate graphs that share a common x-axis.

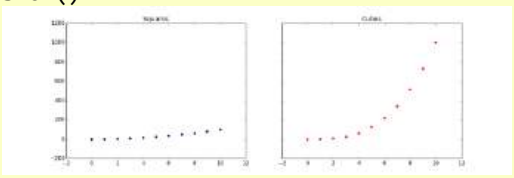
The `plt.subplots()` function returns a figure object and a tuple of axes. Each set of axes corresponds to a separate plot in the figure. The first two arguments control the number of rows and columns generated in the figure.

```
import matplotlib.pyplot as plt

x_vals = list(range(11))
squares = [x**2 for x in x_vals]
cubes = [x**3 for x in x_vals]

fig, axarr = plt.subplots(2, 1, sharex=True)

axarr[0].scatter(x_vals, squares)
axarr[0].set_title('Squares')

axarr[1].scatter(x_vals, cubes, c='red')
axarr[1].set_title('Cubes')

plt.show()
```

Sharing a y-axis

To share a y-axis, we use the `sharey=True` argument.

```
import matplotlib.pyplot as plt

x_vals = list(range(11))
squares = [x**2 for x in x_vals]
cubes = [x**3 for x in x_vals]

fig, axarr = plt.subplots(1, 2, sharey=True)

axarr[0].scatter(x_vals, squares)
axarr[0].set_title('Squares')

axarr[1].scatter(x_vals, cubes, c='red')
axarr[1].set_title('Cubes')

plt.show()
```



More cheat sheets available at
ehmatthes.github.io/pcc/

Python For Data Science *Cheat Sheet*

Seaborn

Learn Data Science Interactively at www.DataCamp.com

Statistical Data Visualization With Seaborn

The Python visualization library **Seaborn** is based on matplotlib and provides a high-level interface for drawing attractive statistical graphics.

Make use of the following aliases to import the libraries:

```
>>> import matplotlib.pyplot as plt
>>> import seaborn as sns
```

The basic steps to creating plots with Seaborn are:

1. Prepare some data
2. Control figure aesthetics
3. Plot with Seaborn
4. Further customize your plot

```
>>> import matplotlib.pyplot as plt
>>> import seaborn as sns
>>> tips = sns.load_dataset("tips")                    Step 1
>>> sns.set_style("whitegrid")                         Step 2
>>> g = sns.lmplot(x="tip",                            Step 3
                   y="total_bill",
                   data=tips,
                   aspect=2)
>>> g = (g.set_axis_labels("Tip","Total bill(USD)").
set(xlim=(0,10),ylim=(0,100)))                         Step 4
>>> plt.title("title")
>>> plt.show(g)                                        Step 5
```

1 Data

Also see Lists, NumPy & Pandas

```
>>> import pandas as pd
>>> import numpy as np
>>> uniform_data = np.random.rand(10, 12)
>>> data = pd.DataFrame({'x':np.arange(1,101),
                         'y':np.random.normal(0,4,100)})
```

Seaborn also offers built-in data sets:

```
>>> titanic = sns.load_dataset("titanic")
>>> iris = sns.load_dataset("iris")
```

2 Figure Aesthetics

Also see Matplotlib

```
>>> f, ax = plt.subplots(figsize=(5,6))
```
Create a figure and one subplot

Seaborn styles

```
>>> sns.set()
>>> sns.set_style("whitegrid")
>>> sns.set_style("ticks",
                  {"xtick.major.size":8,
                   "ytick.major.size":8})
>>> sns.axes_style("whitegrid")
```
(Re)set the seaborn default
Set the matplotlib parameters
Set the matplotlib parameters

Return a dict of params or use with `with` to temporarily set the style

Context Functions

```
>>> sns.set_context("talk")
>>> sns.set_context("notebook",
                    font_scale=1.5,
                    rc={"lines.linewidth":2.5})
```
Set context to `"talk"`
Set context to `"notebook"`, scale font elements and override param mapping

Color Palette

```
>>> sns.set_palette("husl",3)
>>> sns.color_palette("husl")
>>> flatui = ["#9b59b6","#3498db","#95a5a6","#e74c3c","#34495e","#2ecc71"]
>>> sns.set_palette(flatui)
```
Define the color palette
Use with `with` to temporarily set palette
Set your own color palette

3 Plotting With Seaborn

Axis Grids

```
>>> g = sns.FacetGrid(titanic,
                      col="survived",
                      row="sex")
>>> g = g.map(plt.hist,"age")
```
Subplot grid for plotting conditional relationships

```
>>> sns.factorplot(x="pclass",
                   y="survived",
                   hue="sex",
                   data=titanic)
```
Draw a categorical plot onto a Facetgrid

```
>>> sns.lmplot(x="sepal_width",
               y="sepal_length",
               hue="species",
               data=iris)
```
Plot data and regression model fits across a FacetGrid

```
>>> h = sns.PairGrid(iris)
>>> h = h.map(plt.scatter)
>>> sns.pairplot(iris)
```
Subplot grid for plotting pairwise relationships
Plot pairwise bivariate distributions

```
>>> i = sns.JointGrid(x="x",
                      y="y",
                      data=data)
>>> i = i.plot(sns.regplot,
               sns.distplot)
```
Grid for bivariate plot with marginal univariate plots

```
>>> sns.jointplot("sepal_length",
                  "sepal_width",
                  data=iris,
                  kind='kde')
```
Plot bivariate distribution

Categorical Plots

Scatterplot

```
>>> sns.stripplot(x="species",
                  y="petal_length",
                  data=iris)
```
Scatterplot with one categorical variable

```
>>> sns.swarmplot(x="species",
                  y="petal_length",
                  data=iris)
```
Categorical scatterplot with non-overlapping points

Bar Chart

```
>>> sns.barplot(x="sex",
                y="survived",
                hue="class",
                data=titanic)
```
Show point estimates and confidence intervals with scatterplot glyphs

Count Plot

```
>>> sns.countplot(x="deck",
                  data=titanic,
                  palette="Greens_d")
```
Show count of observations

Point Plot

```
>>> sns.pointplot(x="class",
                  y="survived",
                  hue="sex",
                  data=titanic,
                  palette={"male":"g",
                           "female":"m"},
                  markers=["^","o"],
                  linestyles=["-","--"])
```
Show point estimates and confidence intervals as rectangular bars

Boxplot

```
>>> sns.boxplot(x="alive",
                y="age",
                hue="adult_male",
                data=titanic)
```
Boxplot

```
>>> sns.boxplot(data=iris,orient="h")
```
Boxplot with wide-form data

Violinplot

```
>>> sns.violinplot(x="age",
                   y="sex",
                   hue="survived",
                   data=titanic)
```
Violin plot

Regression Plots

```
>>> sns.regplot(x="sepal_width",
                y="sepal_length",
                data=iris,
                ax=ax)
```
Plot data and a linear regression model fit

Distribution Plots

```
>>> plot = sns.distplot(data.y,
                        kde=False,
                        color="b")
```
Plot univariate distribution

Matrix Plots

```
>>> sns.heatmap(uniform_data,vmin=0,vmax=1)
```
Heatmap

4 Further Customizations

Also see Matplotlib

Axisgrid Objects

```
>>> g.despine(left=True)
>>> g.set_ylabels("Survived")
>>> g.set_xticklabels(rotation=45)
>>> g.set_axis_labels("Survived",
                      "Sex")
```
Remove left spine
Set the labels of the y-axis
Set the tick labels for x
Set the axis labels

```
>>> h.set(xlim=(0,5),
          ylim=(0,5),
          xticks=[0,2.5,5],
          yticks=[0,2.5,5])
```
Set the limit and ticks of the x-and y-axis

Plot

```
>>> plt.title("A Title")
>>> plt.ylabel("Survived")
>>> plt.xlabel("Sex")
>>> plt.ylim(0,100)
>>> plt.xlim(0,10)
>>> plt.setp(ax,yticks=[0,5])
>>> plt.tight_layout()
```
Add plot title
Adjust the label of the y-axis
Adjust the label of the x-axis
Adjust the limits of the y-axis
Adjust the limits of the x-axis
Adjust a plot property
Adjust subplot params

5 Show or Save Plot

Also see Matplotlib

```
>>> plt.show()
>>> plt.savefig("foo.png")
>>> plt.savefig("foo.png",
                transparent=True)
```
Show the plot
Save the plot as a figure
Save transparent figure

Close & Clear

Also see Matplotlib

```
>>> plt.cla()
>>> plt.clf()
>>> plt.close()
```
Clear an axis
Clear an entire figure
Close a window

Beginner's Python Cheat Sheet — Pygal

What is Pygal?

Data visualization involves exploring data through visual representations. Pygal helps you make visually appealing representations of the data you're working with. Pygal is particularly well suited for visualizations that will be presented online, because it supports interactive elements.

Installing Pygal

Pygal can be installed using pip.

Pygal on Linux and OS X

```
$ pip install --user pygal
```

Pygal on Windows

```
> python -m pip install --user pygal
```

Line graphs, scatter plots, and bar graphs

To make a plot with Pygal, you specify the kind of plot and then add the data.

Making a line graph

To view the output, open the file squares.svg in a browser.

```
import pygal

x_values = [0, 1, 2, 3, 4, 5]
squares = [0, 1, 4, 9, 16, 25]

chart = pygal.Line()
chart.force_uri_protocol = 'http'
chart.add('x^2', squares)
chart.render_to_file('squares.svg')
```

Adding labels and a title

```
--snip--
chart = pygal.Line()
chart.force_uri_protocol = 'http'
chart.title = "Squares"
chart.x_labels = x_values
chart.x_title = "Value"
chart.y_title = "Square of Value"
chart.add('x^2', squares)
chart.render_to_file('squares.svg')
```

Line graphs, scatter plots, and bar graphs (cont.)

Making a scatter plot

The data for a scatter plot needs to be a list containing tuples of the form (x, y). The `stroke=False` argument tells Pygal to make an XY chart with no line connecting the points.

```
import pygal

squares = [
    (0, 0), (1, 1), (2, 4), (3, 9),
    (4, 16), (5, 25),
    ]

chart = pygal.XY(stroke=False)
chart.force_uri_protocol = 'http'
chart.add('x^2', squares)
chart.render_to_file('squares.svg')
```

Using a list comprehension for a scatter plot

A list comprehension can be used to effficiently make a dataset for a scatter plot.

```
squares = [(x, x**2) for x in range(1000)]
```

Making a bar graph

A bar graph requires a list of values for the bar sizes. To label the bars, pass a list of the same length to `x_labels`.

```
import pygal

outcomes = [1, 2, 3, 4, 5, 6]
frequencies = [18, 16, 18, 17, 18, 13]

chart = pygal.Bar()
chart.force_uri_protocol = 'http'
chart.x_labels = outcomes
chart.add('D6', frequencies)
chart.render_to_file('rolling_dice.svg')
```

Making a bar graph from a dictionary

Since each bar needs a label and a value, a dictionary is a great way to store the data for a bar graph. The keys are used as the labels along the x-axis, and the values are used to determine the height of each bar.

```
import pygal

results = {
    1:18, 2:16, 3:18,
    4:17, 5:18, 6:13,
    }

chart = pygal.Bar()
chart.force_uri_protocol = 'http'
chart.x_labels = results.keys()
chart.add('D6', results.values())
chart.render_to_file('rolling_dice.svg')
```

Multiple plots

You can add as much data as you want when making a visualization.

Plotting squares and cubes

```
import pygal

x_values = list(range(11))
squares = [x**2 for x in x_values]
cubes = [x**3 for x in x_values]

chart = pygal.Line()
chart.force_uri_protocol = 'http'
chart.title = "Squares and Cubes"
chart.x_labels = x_values

chart.add('Squares', squares)
chart.add('Cubes', cubes)
chart.render_to_file('squares_cubes.svg')
```

Filling the area under a data series

Pygal allows you to fill the area under or over each series of data. The default is to fill from the x-axis up, but you can fill from any horizontal line using the `zero` argument.

```
chart = pygal.Line(fill=True, zero=0)
```

Online resources

The documentation for Pygal is available at http://www.pygal.org/.

Enabling interactive features

If you're viewing svg output in a browser, Pygal needs to render the output file in a specific way. The `force_uri_protocol` attribute for chart objects needs to be set to `'http'`.

Styling plots

Pygal lets you customize many elements of a plot. There are some excellent default themes, and many options for styling individual plot elements.

Using built-in styles

To use built-in styles, import the style and make an instance of the style class. Then pass the style object with the `style` argument when you make the chart object.

```
import pygal
from pygal.style import LightGreenStyle

x_values = list(range(11))
squares = [x**2 for x in x_values]
cubes = [x**3 for x in x_values]

chart_style = LightGreenStyle()
chart = pygal.Line(style=chart_style)
chart.force_uri_protocol = 'http'
chart.title = "Squares and Cubes"
chart.x_labels = x_values

chart.add('Squares', squares)
chart.add('Cubes', cubes)
chart.render_to_file('squares_cubes.svg')
```

Parametric built-in styles

Some built-in styles accept a custom color, then generate a theme based on that color.

```
from pygal.style import LightenStyle

--snip--
chart_style = LightenStyle('#336688')
chart = pygal.Line(style=chart_style)
--snip--
```

Customizing individual style properties

Style objects have a number of properties you can set individually.

```
chart_style = LightenStyle('#336688')
chart_style.plot_background = '#CCCCCC'
chart_style.major_label_font_size = 20
chart_style.label_font_size = 16
--snip--
```

Custom style class

You can start with a bare style class, and then set only the properties you care about.

```
chart_style = Style()
chart_style.colors = [
    '#CCCCCC', '#AAAAAA', '#888888']
chart_style.plot_background = '#EEEEEE'

chart = pygal.Line(style=chart_style)
--snip--
```

Styling plots (cont.)

Configuration settings

Some settings are controlled by a `Config` object.

```
my_config = pygal.Config()
my_config.show_y_guides = False
my_config.width = 1000
my_config.dots_size = 5

chart = pygal.Line(config=my_config)
--snip--
```

Styling series

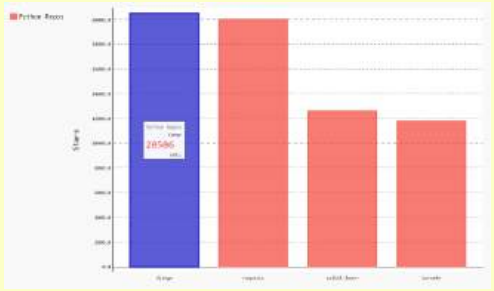
You can give each series on a chart different style settings.

```
chart.add('Squares', squares, dots_size=2)
chart.add('Cubes', cubes, dots_size=3)
```

Styling individual data points

You can style individual data points as well. To do so, write a dictionary for each data point you want to customize. A `'value'` key is required, and other properies are optional.

```
import pygal

repos = [
    {
        'value': 20506,
        'color': '#3333CC',
        'xlink': 'http://djangoproject.com/',
    },
    20054,
    12607,
    11827,
    ]

chart = pygal.Bar()
chart.force_uri_protocol = 'http'
chart.x_labels = [
    'django', 'requests', 'scikit-learn',
    'tornado',
    ]
chart.y_title = 'Stars'
chart.add('Python Repos', repos)
chart.render_to_file('python_repos.svg')
```



Plotting global datasets

Pygal can generate world maps, and you can add any data you want to these maps. Data is indicated by coloring, by labels, and by tooltips that show data when users hover over each country on the map.

Installing the world map module

The world map module is not included by default in Pygal 2.0. It can be installed with pip:

```
$ pip install --user pygal_maps_world
```

Making a world map

The following code makes a simple world map showing the countries of North America.

```
from pygal.maps.world import World

wm = World()
wm.force_uri_protocol = 'http'
wm.title = 'North America'
wm.add('North America', ['ca', 'mx', 'us'])

wm.render_to_file('north_america.svg')
```

Showing all the country codes

In order to make maps, you need to know Pygal's country codes. The following example will print an alphabetical list of each country and its code.

```
from pygal.maps.world import COUNTRIES

for code in sorted(COUNTRIES.keys()):
    print(code, COUNTRIES[code])
```

Plotting numerical data on a world map

To plot numerical data on a map, pass a dictionary to `add()` instead of a list.

```
from pygal.maps.world import World

populations = {
    'ca': 34126000,
    'us': 309349000,
    'mx': 113423000,
    }

wm = World()
wm.force_uri_protocol = 'http'
wm.title = 'Population of North America'
wm.add('North America', populations)

wm.render_to_file('na_populations.svg')
```

More cheat sheets available at
ehmatthes.github.io/pcc/

Python For Data Science *Cheat Sheet*

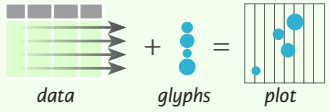
Bokeh

Learn Bokeh Interactively at www.DataCamp.com, taught by Bryan Van de Ven, core contributor

Plotting With Bokeh

The Python interactive visualization library **Bokeh** enables high-performance visual presentation of large datasets in modern web browsers.

Bokeh's mid-level general purpose `bokeh.plotting` interface is centered around two main components: data and glyphs.



The basic steps to creating plots with the `bokeh.plotting` interface are:

1. Prepare some data:

Python lists, NumPy arrays, Pandas DataFrames and other sequences of values

2. Create a new plot
3. Add renderers for your data, with visual customizations
4. Specify where to generate the output
5. Show or save the results

```
>>> from bokeh.plotting import figure
>>> from bokeh.io import output_file, show
>>> x = [1, 2, 3, 4, 5]                                  Step 1
>>> y = [6, 7, 2, 4, 5]
>>> p = figure(title="simple line example",               Step 2
              x_axis_label='x',
              y_axis_label='y')
>>> p.line(x, y, legend="Temp.", line_width=2)           Step 3
>>> output_file("lines.html")                            Step 4
>>> show(p)                                              Step 5
```

1 Data

Also see Lists, NumPy & Pandas

Under the hood, your data is converted to Column Data Sources. You can also do this manually:

```
>>> import numpy as np
>>> import pandas as pd
>>> df = pd.DataFrame(np.array([[33.9,4,65, 'US'],
                                [32.4,4,66, 'Asia'],
                                [21.4,4,109, 'Europe']]),
                      columns=['mpg','cyl', 'hp', 'origin'],
                      index=['Toyota', 'Fiat', 'Volvo'])
```

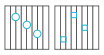
```
>>> from bokeh.models import ColumnDataSource
>>> cds_df = ColumnDataSource(df)
```

2 Plotting

```
>>> from bokeh.plotting import figure
>>> p1 = figure(plot_width=300, tools='pan,box_zoom')
>>> p2 = figure(plot_width=300, plot_height=300,
                x_range=(0, 8), y_range=(0, 8))
>>> p3 = figure()
```

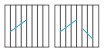
3 Renderers & Visual Customizations

Glyphs



Scatter Markers

```
>>> p1.circle(np.array([1,2,3]), np.array([3,2,1]),
              fill_color='white')
>>> p2.square(np.array([1.5,3.5,5.5]), [1,4,3],
              color='blue', size=1)
```



Line Glyphs

```
>>> p1.line([1,2,3,4], [3,4,5,6], line_width=2)
>>> p2.multi_line(pd.DataFrame([[1,2,3],[5,6,7]]),
                  pd.DataFrame([[3,4,5],[3,2,1]]),
                  color="blue")
```

Customized Glyphs

Also see Data

Selection and Non-Selection Glyphs

```
>>> p = figure(tools='box_select')
>>> p.circle('mpg', 'cyl', source=cds_df,
             selection_color='red',
             nonselection_alpha=0.1)
```

Hover Glyphs

```
>>> from bokeh.models import HoverTool
>>> hover = HoverTool(tooltips=None, mode='vline')
>>> p3.add_tools(hover)
```

Colormapping

```
>>> from bokeh.models import CategoricalColorMapper
>>> color_mapper = CategoricalColorMapper(
                   factors=['US', 'Asia', 'Europe'],
                   palette=['blue', 'red', 'green'])
>>> p3.circle('mpg', 'cyl', source=cds_df,
             color=dict(field='origin',
                        transform=color_mapper),
             legend='Origin')
```

Legend Location

Inside Plot Area

```
>>> p.legend.location = 'bottom_left'
```

Outside Plot Area

```
>>> from bokeh.models import Legend
>>> r1 = p2.asterisk(np.array([1,2,3]), np.array([3,2,1])
>>> r2 = p2.line([1,2,3,4], [3,4,5,6])
>>> legend = Legend(items=[("One" ,[p1, r1]),("Two",[r2])],
                    location=(0, -30))
>>> p.add_layout(legend, 'right')
```

Legend Orientation

```
>>> p.legend.orientation = "horizontal"
>>> p.legend.orientation = "vertical"
```

Legend Background & Border

```
>>> p.legend.border_line_color = "navy"
>>> p.legend.background_fill_color = "white"
```

Rows & Columns Layout

Rows

```
>>> from bokeh.layouts import row
>>> layout = row(p1,p2,p3)
```

Columns

```
>>> from bokeh.layouts import columns
>>> layout = column(p1,p2,p3)
```

Nesting Rows & Columns

```
>>>layout = row(column(p1,p2), p3)
```

Grid Layout

```
>>> from bokeh.layouts import gridplot
>>> row1 = [p1,p2]
>>> row2 = [p3]
>>> layout = gridplot([[p1,p2],[p3]])
```

Tabbed Layout

```
>>> from bokeh.models.widgets import Panel, Tabs
>>> tab1 = Panel(child=p1, title="tab1")
>>> tab2 = Panel(child=p2, title="tab2")
>>> layout = Tabs(tabs=[tab1, tab2])
```

Linked Plots

Linked Axes

```
>>> p2.x_range = p1.x_range
>>> p2.y_range = p1.y_range
```

Linked Brushing

```
>>> p4 = figure(plot_width = 100,
                tools='box_select,lasso_select')
>>> p4.circle('mpg', 'cyl', source=cds_df)
>>> p5 = figure(plot_width = 200,
                tools='box_select,lasso_select')
>>> p5.circle('mpg', 'hp', source=cds_df)
>>> layout = row(p4,p5)
```

4 Output & Export

Notebook

```
>>> from bokeh.io import output_notebook, show
>>> output_notebook()
```

HTML

Standalone HTML

```
>>> from bokeh.embed import file_html
>>> from bokeh.resources import CDN
>>> html = file_html(p, CDN, "my_plot")
```

```
>>> from bokeh.io import output_file, show
>>> output_file('my_bar_chart.html', mode='cdn')
```

Components

```
>>> from bokeh.embed import components
>>> script, div = components(p)
```

PNG

```
>>> from bokeh.io import export_png
>>> export_png(p, filename="plot.png")
```

SVG

```
>>> from bokeh.io import export_svgs
>>> p.output_backend = "svg"
>>> export_svgs(p, filename="plot.svg")
```

5 Show or Save Your Plots

```
>>> show(p1)
>>> save(p1)
```

```
>>> show(layout)
>>> save(layout)
```

Python For Data Science *Cheat Sheet*

Scikit-Learn

Learn Python for data science Interactively at www.DataCamp.com

Scikit-learn

Scikit-learn is an open source Python library that implements a range of machine learning, preprocessing, cross-validation and visualization algorithms using a unified interface.

A Basic Example

```
>>> from sklearn import neighbors, datasets, preprocessing
>>> from sklearn.model_selection import train_test_split
>>> from sklearn.metrics import accuracy_score
>>> iris = datasets.load_iris()
>>> X, y = iris.data[:, :2], iris.target
>>> X_train, X_test, y_train, y_test= train_test_split(X, y, random_state=33)
>>> scaler = preprocessing.StandardScaler().fit(X_train)
>>> X_train = scaler.transform(X_train)
>>> X_test = scaler.transform(X_test)
>>> knn = neighbors.KNeighborsClassifier(n_neighbors=5)
>>> knn.fit(X_train, y_train)
>>> y_pred = knn.predict(X_test)
>>> accuracy_score(y_test, y_pred)
```

Loading The Data

Also see NumPy & Pandas

Your data needs to be numeric and stored as NumPy arrays or SciPy sparse matrices. Other types that are convertible to numeric arrays, such as Pandas DataFrame, are also acceptable.

```
>>> import numpy as np
>>> X = np.random.random((10,5))
>>> y = np.array(['M','M','F','F','M','F','M','M','F','F','F'])
>>> X[X < 0.7] = 0
```

Training And Test Data

```
>>> from sklearn.model_selection import train_test_split
>>> X_train, X_test, y_train, y_test = train_test_split(X,
                                                        y,
                                                        random_state=0)
```

Create Your Model

Supervised Learning Estimators

Linear Regression

```
>>> from sklearn.linear_model import LinearRegression
>>> lr = LinearRegression(normalize=True)
```

Support Vector Machines (SVM)

```
>>> from sklearn.svm import SVC
>>> svc = SVC(kernel='linear')
```

Naive Bayes

```
>>> from sklearn.naive_bayes import GaussianNB
>>> gnb = GaussianNB()
```

KNN

```
>>> from sklearn import neighbors
>>> knn = neighbors.KNeighborsClassifier(n_neighbors=5)
```

Unsupervised Learning Estimators

Principal Component Analysis (PCA)

```
>>> from sklearn.decomposition import PCA
>>> pca = PCA(n_components=0.95)
```

K Means

```
>>> from sklearn.cluster import KMeans
>>> k_means = KMeans(n_clusters=3, random_state=0)
```

Model Fitting

Supervised learning	
`>>> lr.fit(X, y)`	Fit the model to the data
`>>> knn.fit(X_train, y_train)`	
`>>> svc.fit(X_train, y_train)`	
Unsupervised Learning	
`>>> k_means.fit(X_train)`	Fit the model to the data
`>>> pca_model = pca.fit_transform(X_train)`	Fit to data, then transform it

Prediction

Supervised Estimators	
`>>> y_pred = svc.predict(np.random.random((2,5)))`	Predict labels
`>>> y_pred = lr.predict(X_test)`	Predict labels
`>>> y_pred = knn.predict_proba(X_test)`	Estimate probability of a label
Unsupervised Estimators	
`>>> y_pred = k_means.predict(X_test)`	Predict labels in clustering algos

Preprocessing The Data

Standardization

```
>>> from sklearn.preprocessing import StandardScaler
>>> scaler = StandardScaler().fit(X_train)
>>> standardized_X = scaler.transform(X_train)
>>> standardized_X_test = scaler.transform(X_test)
```

Normalization

```
>>> from sklearn.preprocessing import Normalizer
>>> scaler = Normalizer().fit(X_train)
>>> normalized_X = scaler.transform(X_train)
>>> normalized_X_test = scaler.transform(X_test)
```

Binarization

```
>>> from sklearn.preprocessing import Binarizer
>>> binarizer = Binarizer(threshold=0.0).fit(X)
>>> binary_X = binarizer.transform(X)
```

Encoding Categorical Features

```
>>> from sklearn.preprocessing import LabelEncoder
>>> enc = LabelEncoder()
>>> y = enc.fit_transform(y)
```

Imputing Missing Values

```
>>> from sklearn.preprocessing import Imputer
>>> imp = Imputer(missing_values=0, strategy='mean', axis=0)
>>> imp.fit_transform(X_train)
```

Generating Polynomial Features

```
>>> from sklearn.preprocessing import PolynomialFeatures
>>> poly = PolynomialFeatures(5)
>>> poly.fit_transform(X)
```

Evaluate Your Model's Performance

Classification Metrics

Accuracy Score

```
>>> knn.score(X_test, y_test)
```
Estimator score method

```
>>> from sklearn.metrics import accuracy_score
>>> accuracy_score(y_test, y_pred)
```
Metric scoring functions

Classification Report

```
>>> from sklearn.metrics import classification_report
>>> print(classification_report(y_test, y_pred))
```
Precision, recall, f1-score and support

Confusion Matrix

```
>>> from sklearn.metrics import confusion_matrix
>>> print(confusion_matrix(y_test, y_pred))
```

Regression Metrics

Mean Absolute Error

```
>>> from sklearn.metrics import mean_absolute_error
>>> y_true = [3, -0.5, 2]
>>> mean_absolute_error(y_true, y_pred)
```

Mean Squared Error

```
>>> from sklearn.metrics import mean_squared_error
>>> mean_squared_error(y_test, y_pred)
```

R^2 Score

```
>>> from sklearn.metrics import r2_score
>>> r2_score(y_true, y_pred)
```

Clustering Metrics

Adjusted Rand Index

```
>>> from sklearn.metrics import adjusted_rand_score
>>> adjusted_rand_score(y_true, y_pred)
```

Homogeneity

```
>>> from sklearn.metrics import homogeneity_score
>>> homogeneity_score(y_true, y_pred)
```

V-measure

```
>>> from sklearn.metrics import v_measure_score
>>> metrics.v_measure_score(y_true, y_pred)
```

Cross-Validation

```
>>> from sklearn.cross_validation import cross_val_score
>>> print(cross_val_score(knn, X_train, y_train, cv=4))
>>> print(cross_val_score(lr, X, y, cv=2))
```

Tune Your Model

Grid Search

```
>>> from sklearn.grid_search import GridSearchCV
>>> params = {"n_neighbors": np.arange(1,3),
              "metric": ["euclidean", "cityblock"]}
>>> grid = GridSearchCV(estimator=knn,
                        param_grid=params)
>>> grid.fit(X_train, y_train)
>>> print(grid.best_score_)
>>> print(grid.best_estimator_.n_neighbors)
```

Randomized Parameter Optimization

```
>>> from sklearn.grid_search import RandomizedSearchCV
>>> params = {"n_neighbors": range(1,5),
              "weights": ["uniform", "distance"]}
>>> rsearch = RandomizedSearchCV(estimator=knn,
                                 param_distributions=params,
                                 cv=4,
                                 n_iter=8,
                                 random_state=5)
>>> rsearch.fit(X_train, y_train)
>>> print(rsearch.best_score_)
```

Python For Data Science *Cheat Sheet*

SciPy - Linear Algebra

Learn More Python for Data Science Interactively at www.datacamp.com

SciPy

The **SciPy** library is one of the core packages for scientific computing that provides mathematical algorithms and convenience functions built on the NumPy extension of Python.

Interacting With NumPy

Also see NumPy

```
>>> import numpy as np
>>> a = np.array([1,2,3])
>>> b = np.array([(1+5j,2j,3j), (4j,5j,6j)])
>>> c = np.array([[(1.5,2,3), (4,5,6)], [(3,2,1), (4,5,6)]])
```

Index Tricks

```
>>> np.mgrid[0:5,0:5]          Create a dense meshgrid
>>> np.ogrid[0:2,0:2]          Create an open meshgrid
>>> np.r_[[3,[0]*5,-1:1:10j]   Stack arrays vertically (row-wise)
>>> np.c_[b,c]                 Create stacked column-wise arrays
```

Shape Manipulation

```
>>> np.transpose(b)            Permute array dimensions
>>> b.flatten()                Flatten the array
>>> np.hstack((b,c))           Stack arrays horizontally (column-wise)
>>> np.vstack((a,b))           Stack arrays vertically (row-wise)
>>> np.hsplit(c,2)             Split the array horizontally at the 2nd index
>>> np.vpslit(d,2)             Split the array vertically at the 2nd index
```

Polynomials

```
>>> from numpy import poly1d
>>> p = poly1d([3,4,5])        Create a polynomial object
```

Vectorizing Functions

```
>>> def myfunc(a):
        if a < 0:
          return a*2
        else:
          return a/2
>>> np.vectorize(myfunc)       Vectorize functions
```

Type Handling

```
>>> np.real(c)                 Return the real part of the array elements
>>> np.imag(c)                 Return the imaginary part of the array elements
>>> np.real_if_close(c,tol=1000)  Return a real array if complex parts close to 0
>>> np.cast['f'](np.pi)        Cast object to a data type
```

Other Useful Functions

```
>>> np.angle(b,deg=True)       Return the angle of the complex argument
>>> g = np.linspace(0,np.pi,num=5)  Create an array of evenly spaced values
                                    (number of samples)
>>> g [3:] += np.pi
>>> np.unwrap(g)               Unwrap
>>> np.logspace(0,10,3)        Create an array of evenly spaced values (log scale)
>>> np.select([c<4],[c*2])     Return values from a list of arrays depending on
                               conditions
>>> misc.factorial(a)          Factorial
>>> misc.comb(10,3,exact=True)  Combine N things taken at k time
>>> misc.central_diff_weights(3)  Weights for Np-point central derivative
>>> misc.derivative(myfunc,1.0)  Find the n-th derivative of a function at a point
```

Linear Algebra

Also see NumPy

You'll use the `linalg` and `sparse` modules. Note that `scipy.linalg` contains and expands on `numpy.linalg`.

```
>>> from scipy import linalg, sparse
```

Creating Matrices

```
>>> A = np.matrix(np.random.random((2,2)))
>>> B = np.asmatrix(b)
>>> C = np.mat(np.random.random((10,5)))
>>> D = np.mat([[3,4], [5,6]])
```

Basic Matrix Routines

Inverse

```
>>> A.I                        Inverse
>>> linalg.inv(A)              Inverse
>>> A.T                        Tranpose matrix
>>> A.H                        Conjugate transposition
>>> np.trace(A)                Trace
```

Norm

```
>>> linalg.norm(A)             Frobenius norm
>>> linalg.norm(A,1)           L1 norm (max column sum)
>>> linalg.norm(A,np.inf)      L inf norm (max row sum)
```

Rank

```
>>> np.linalg.matrix_rank(C)   Matrix rank
```

Determinant

```
>>> linalg.det(A)              Determinant
```

Solving linear problems

```
>>> linalg.solve(A,b)          Solver for dense matrices
>>> E = np.mat(a).T            Solver for dense matrices
>>> linalg.lstsq(D,E)          Least-squares solution to linear matrix
                               equation
```

Generalized inverse

```
>>> linalg.pinv(C)             Compute the pseudo-inverse of a matrix
                               (least-squares solver)
>>> linalg.pinv2(C)            Compute the pseudo-inverse of a matrix
                               (SVD)
```

Creating Sparse Matrices

```
>>> F = np.eye(3, k=1)         Create a 2X2 identity matrix
>>> G = np.mat(np.identity(2)) Create a 2x2 identity matrix
>>> C[C > 0.5] = 0
>>> H = sparse.csr_matrix(C)   Compressed Sparse Row matrix
>>> I = sparse.csc_matrix(D)   Compressed Sparse Column matrix
>>> J = sparse.dok_matrix(A)   Dictionary Of Keys matrix
>>> E.todense()                Sparse matrix to full matrix
>>> sparse.isspmatrix_csc(A)   Identify sparse matrix
```

Sparse Matrix Routines

Inverse

```
>>> sparse.linalg.inv(I)       Inverse
```

Norm

```
>>> sparse.linalg.norm(I)      Norm
```

Solving linear problems

```
>>> sparse.linalg.spsolve(H,I)  Solver for sparse matrices
```

Sparse Matrix Functions

```
>>> sparse.linalg.expm(I)      Sparse matrix exponential
```

Matrix Functions

Addition

```
>>> np.add(A,D)                Addition
```

Subtraction

```
>>> np.subtract(A,D)           Subtraction
```

Division

```
>>> np.divide(A,D)             Division
```

Multiplication

```
>>> np.multiply(D,A)           Multiplication
>>> np.dot(A,D)                Dot product
>>> np.vdot(A,D)               Vector dot product
>>> np.inner(A,D)              Inner product
>>> np.outer(A,D)              Outer product
>>> np.tensordot(A,D)          Tensor dot product
>>> np.kron(A,D)               Kronecker product
```

Exponential Functions

```
>>> linalg.expm(A)             Matrix exponential
>>> linalg.expm2(A)            Matrix exponential (Taylor Series)
>>> linalg.expm3(D)            Matrix exponential (eigenvalue
                               decomposition)
```

Logarithm Function

```
>>> linalg.logm(A)             Matrix logarithm
```

Trigonometric Tunctions

```
>>> linalg.sinm(D)             Matrix sine
>>> linalg.cosm(D)             Matrix cosine
>>> linalg.tanm(A)             Matrix tangent
```

Hyperbolic Trigonometric Functions

```
>>> linalg.sinhm(D)            Hypberbolic matrix sine
>>> linalg.coshm(D)            Hyperbolic matrix cosine
>>> linalg.tanhm(A)            Hyperbolic matrix tangent
```

Matrix Sign Function

```
>>> np.sigm(A)                 Matrix sign function
```

Matrix Square Root

```
>>> linalg.sqrtm(A)            Matrix square root
```

Arbitrary Functions

```
>>> linalg.funm(A, lambda x: x*x)  Evaluate matrix function
```

Decompositions

Eigenvalues and Eigenvectors

```
>>> la, v = linalg.eig(A)      Solve ordinary or generalized
                               eigenvalue problem for square matrix
>>> l1, l2 = la                Unpack eigenvalues
>>> v[:,0]                     First eigenvector
>>> v[:,1]                     Second eigenvector
>>> linalg.eigvals(A)          Unpack eigenvalues
```

Singular Value Decomposition

```
>>> U,s,Vh = linalg.svd(B)     Singular Value Decomposition (SVD)
>>> M,N = B.shape
>>> Sig = linalg.diagsvd(s,M,N)  Construct sigma matrix in SVD
```

LU Decomposition

```
>>> P,L,U = linalg.lu(C)       LU Decomposition
```

Sparse Matrix Decompositions

```
>>> la, v = sparse.linalg.eigs(F,1)  Eigenvalues and eigenvectors
>>> sparse.linalg.svds(H, 2)         SVD
```

Asking For Help

```
>>> help(scipy.linalg.diagsvd)
>>> np.info(np.matrix)
```

Python for Data Science Cheat Sheet spaCy

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DataCamp

About spaCy

spaCy is a free, open-source library for advanced Natural Language Processing (NLP) in Python. It's designed specifically for production use and helps you build applications that process and "understand" large volumes of text. **Documentation:** spacy.io

```
$ pip install spacy
```

```
import spacy
```

Statistical models

Download statistical models

Predict part-of-speech tags, dependency labels, named entities and more. See here for available models: spacy.io/models

```
$ python -m spacy download en_core_web_sm
```

Check that your installed models are up to date

```
$ python -m spacy validate
```

Loading statistical models

```
import spacy
# Load the installed model "en_core_web_sm"
nlp = spacy.load("en_core_web_sm")
```

Documents and tokens

Processing text

Processing text with the `nlp` object returns a `Doc` object that holds all information about the tokens, their linguistic features and their relationships

```
doc = nlp("This is a text")
```

Accessing token attributes

```
doc = nlp("This is a text")
# Token texts
[token.text for token in doc]
# ['This', 'is', 'a', 'text']
```

Spans

Accessing spans

Span indices are **exclusive**. So `doc[2:4]` is a span starting at token 2, up to – but not including! – token 4.

```
doc = nlp("This is a text")
span = doc[2:4]
span.text
# 'a text'
```

Creating a span manually

```
# Import the Span object
from spacy.tokens import Span
# Create a Doc object
doc = nlp("I live in New York")
# Span for "New York" with label GPE (geopolitical)
span = Span(doc, 3, 5, label="GPE")
span.text
# 'New York'
```

Linguistic features

Attributes return label IDs. For string labels, use the attributes with an underscore. For example, `token.pos_` .

Part-of-speech tags

PREDICTED BY STATISTICAL MODEL

```
doc = nlp("This is a text.")
# Coarse-grained part-of-speech tags
[token.pos_ for token in doc]
# ['DET', 'VERB', 'DET', 'NOUN', 'PUNCT']
# Fine-grained part-of-speech tags
[token.tag_ for token in doc]
# ['DT', 'VBZ', 'DT', 'NN', '.']
```

Syntactic dependencies

PREDICTED BY STATISTICAL MODEL

```
doc = nlp("This is a text.")
# Dependency labels
[token.dep_ for token in doc]
# ['nsubj', 'ROOT', 'det', 'attr', 'punct']
# Syntactic head token (governor)
[token.head.text for token in doc]
# ['is', 'is', 'text', 'is', 'is']
```

Named entities

PREDICTED BY STATISTICAL MODEL

```
doc = nlp("Larry Page founded Google")
# Text and label of named entity span
[(ent.text, ent.label_) for ent in doc.ents]
# [('Larry Page', 'PERSON'), ('Google', 'ORG')]
```

Syntax iterators

Sentences

USUALLY NEEDS THE DEPENDENCY PARSER

```
doc = nlp("This a sentence. This is another one.")
# doc.sents is a generator that yields sentence spans
[sent.text for sent in doc.sents]
# ['This is a sentence.', 'This is another one.']
```

Base noun phrases

NEEDS THE TAGGER AND PARSER

```
doc = nlp("I have a red car")
# doc.noun_chunks is a generator that yields spans
[chunk.text for chunk in doc.noun_chunks]
# ['I', 'a red car']
```

Label explanations

```
spacy.explain("RB")
# 'adverb'
spacy.explain("GPE")
# 'Countries, cities, states'
```

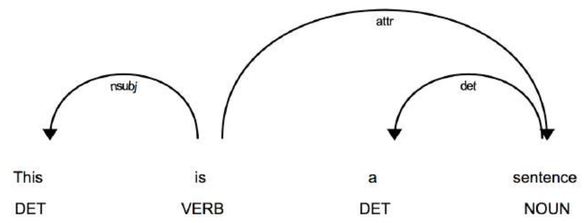
Visualizing

If you're in a Jupyter notebook, use `displacy.render` . Otherwise, use `displacy.serve` to start a web server and show the visualization in your browser.

```
from spacy import displacy
```

Visualize dependencies

```
doc = nlp("This is a sentence")
displacy.render(doc, style="dep")
```



Visualize named entities

```
doc = nlp("Larry Page founded Google")
displacy.render(doc, style="ent")
```

Larry Page PERSON founded Google ORG

Word vectors and similarity

To use word vectors, you need to install the larger models ending in `md` or `lg`, for example `en_core_web_lg`.

Comparing similarity

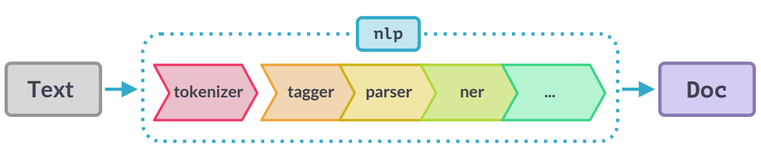
```
doc1 = nlp("I like cats")
doc2 = nlp("I like dogs")
# Compare 2 documents
doc1.similarity(doc2)
# Compare 2 tokens
doc1[2].similarity(doc2[2])
# Compare tokens and spans
doc1[0].similarity(doc2[1:3])
```

Accessing word vectors

```
# Vector as a numpy array
doc = nlp("I like cats")
# The L2 norm of the token's vector
doc[2].vector
doc[2].vector_norm
```

Pipeline components

Functions that take a `Doc` object, modify it and return it.



Pipeline information

```
nlp = spacy.load("en_core_web_sm")
nlp.pipe_names
# ['tagger', 'parser', 'ner']
nlp.pipeline
# [('tagger', <spacy.pipeline.Tagger>),
#  ('parser', <spacy.pipeline.DependencyParser>),
#  ('ner', <spacy.pipeline.EntityRecognizer>)]
```

Custom components

```
# Function that modifies the doc and returns it
def custom_component(doc):
    print("Do something to the doc here!")
    return doc

# Add the component first in the pipeline
nlp.add_pipe(custom_component, first=True)
```

Components can be added `first`, `last` (default), or `before` or `after` an existing component.

Extension attributes

Custom attributes that are registered on the global `Doc`, `Token` and `Span` classes and become available as `._`.

```
from spacy.tokens import Doc, Token, Span
doc = nlp("The sky over New York is blue")
```

Attribute extensions

WITH DEFAULT VALUE

```
# Register custom attribute on Token class
Token.set_extension("is_color", default=False)
# Overwrite extension attribute with default value
doc[6]._.is_color = True
```

Property extensions

WITH GETTER & SETTER

```
# Register custom attribute on Doc class
get_reversed = lambda doc: doc.text[::-1]
Doc.set_extension("reversed", getter=get_reversed)
# Compute value of extension attribute with getter
doc._.reversed
# 'eulb si kroY weN revo yks ehT'
```

Method extensions

CALLABLE METHOD

```
# Register custom attribute on Span class
has_label = lambda span, label: span.label_ == label
Span.set_extension("has_label", method=has_label)
# Compute value of extension attribute with method
doc[3:5].has_label("GPE")
# True
```

Rule-based matching

Using the matcher

```
# Matcher is initialized with the shared vocab
from spacy.matcher import Matcher
# Each dict represents one token and its attributes
matcher = Matcher(nlp.vocab)
# Add with ID, optional callback and pattern(s)
pattern = [{"LOWER": "new"}, {"LOWER": "york"}]
matcher.add("CITIES", None, pattern)
# Match by calling the matcher on a Doc object
doc = nlp("I live in New York")
matches = matcher(doc)
# Matches are (match_id, start, end) tuples
for match_id, start, end in matches:
    # Get the matched span by slicing the Doc
    span = doc[start:end]
    print(span.text)
# 'New York'
```

Rule-based matching

Token patterns

```
# "love cats", "loving cats", "loved cats"
pattern1 = [{"LEMMA": "love"}, {"LOWER": "cats"}]
# "10 people", "twenty people"
pattern2 = [{"LIKE_NUM": True}, {"TEXT": "people"}]
# "book", "a cat", "the sea" (noun + optional article)
pattern3 = [{"POS": "DET", "OP": "?"}, {"POS": "NOUN"}]
```

Operators and quantifiers

Can be added to a token dict as the `"OP"` key.

`!`	Negate pattern and match **exactly 0 times**.
`?`	Make pattern optional and match **0 or 1 times**.
`+`	Require pattern to match **1 or more times**.
`*`	Allow pattern to match **0 or more times**.

Glossary

Tokenization	Segmenting text into words, punctuation etc.
Lemmatization	Assigning the base forms of words, for example: "was" → "be" or "rats" → "rat".
Sentence Boundary Detection	Finding and segmenting individual sentences.
Part-of-speech (POS) Tagging	Assigning word types to tokens like verb or noun.
Dependency Parsing	Assigning syntactic dependency labels, describing the relations between individual tokens, like subject or object.
Named Entity Recognition (NER)	Labeling named "real-world" objects, like persons, companies or locations.
Text Classification	Assigning categories or labels to a whole document, or parts of a document.
Statistical model	Process for making predictions based on examples.
Training	Updating a statistical model with new examples.

Python For Data Science *Cheat Sheet*

PySpark - SQL Basics

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PySpark & Spark SQL

Spark SQL is Apache Spark's module for working with structured data.

Initializing SparkSession

A SparkSession can be used create DataFrame, register DataFrame as tables, execute SQL over tables, cache tables, and read parquet files.

```
>>> from pyspark.sql import SparkSession
>>> spark = SparkSession \
        .builder \
        .appName("Python Spark SQL basic example") \
        .config("spark.some.config.option", "some-value") \
        .getOrCreate()
```

Creating DataFrames

From RDDs

```
>>> from pyspark.sql.types import *
```

Infer Schema

```
>>> sc = spark.sparkContext
>>> lines = sc.textFile("people.txt")
>>> parts = lines.map(lambda l: l.split(","))
>>> people = parts.map(lambda p: Row(name=p[0],age=int(p[1])))
>>> peopledf = spark.createDataFrame(people)
```

Specify Schema

```
>>> people = parts.map(lambda p: Row(name=p[0],
                                     age=int(p[1].strip())))
>>> schemaString = "name age"
>>> fields = [StructField(field_name, StringType(), True) for
field_name in schemaString.split()]
>>> schema = StructType(fields)
>>> spark.createDataFrame(people, schema).show()
  +--------+---+
  |    name|age|
  +--------+---+
  |    Mine| 28|
  |   Filip| 29|
  |Jonathan| 30|
  +--------+---+
```

From Spark Data Sources

JSON

```
>>> df = spark.read.json("customer.json")
>>> df.show()
 +--------------------+---+---------+--------+--------------------+
 |             address|age|firstName |lastName|         phoneNumber|
 +--------------------+---+---------+--------+--------------------+
 |[New York,10021,N...| 25|     John|   Smith|[[212 555-1234,ho...|
 |[New York,10021,N...| 21|     Jane|     Doe|[[322 888-1234,ho...|
 +--------------------+---+---------+--------+--------------------+
>>> df2 = spark.read.load("people.json", format="json")
```

Parquet files

```
>>> df3 = spark.read.load("users.parquet")
```

TXT files

```
>>> df4 = spark.read.text("people.txt")
```

Duplicate Values

```
>>> df = df.dropDuplicates()
```

Queries

```
>>> from pyspark.sql import functions as F
```

Select

```
>>> df.select("firstName").show()
>>> df.select("firstName","lastName") \
      .show()
>>> df.select("firstName",
              "age",
               explode("phoneNumber") \
              .alias("contactInfo")) \
      .select("contactInfo.type",
              "firstName",
              "age") \
      .show()
>>> df.select(df["firstName"],df["age"]+ 1)
      .show()
>>> df.select(df['age'] > 24).show()
```

When

```
>>> df.select("firstName",
              F.when(df.age > 30, 1) \
              .otherwise(0)) \
      .show()
>>> df[df.firstName.isin("Jane","Boris")]
                .collect()
```

Like

```
>>> df.select("firstName",
              df.lastName.like("Smith")) \
      .show()
```

Startswith - Endswith

```
>>> df.select("firstName",
              df.lastName \
                .startswith("Sm")) \
      .show()
>>> df.select(df.lastName.endswith("th")) \
      .show()
```

Substring

```
>>> df.select(df.firstName.substr(1, 3) \
                       .alias("name")) \
      .collect()
```

Between

```
>>> df.select(df.age.between(22, 24)) \
      .show()
```

Show all entries in `firstName` column

Show all entries in `firstName`, `age` and `type`

Show all entries in `firstName` and `age`, add `1` to the entries of `age`
Show all entries where `age` >24

Show `firstName` and 0 or 1 depending on `age` >30

Show `firstName` if in the given options

Show `firstName`, and `lastName` is `TRUE` if `lastName` is like `Smith`

Show `firstName`, and `TRUE` if `lastName` starts with `Sm`

Show last names ending in `th`

Return substrings of `firstName`

Show `age`: values are `TRUE` if between `22` and `24`

Add, Update & Remove Columns

Adding Columns

```
>>> df = df.withColumn('city',df.address.city) \
           .withColumn('postalCode',df.address.postalCode) \
           .withColumn('state',df.address.state) \
           .withColumn('streetAddress',df.address.streetAddress) \
           .withColumn('telePhoneNumber',
                       explode(df.phoneNumber.number)) \
           .withColumn('telePhoneType',
                       explode(df.phoneNumber.type))
```

Updating Columns

```
>>> df = df.withColumnRenamed('telePhoneNumber', 'phoneNumber')
```

Removing Columns

```
>>> df = df.drop("address", "phoneNumber")
>>> df = df.drop(df.address).drop(df.phoneNumber)
```

GroupBy

```
>>> df.groupBy("age")\
      .count() \
      .show()
```

Group by `age`, count the members in the groups

Filter

```
>>> df.filter(df["age"]>24).show()
```

Filter entries of `age`, only keep those records of which the values are `>24`

Sort

```
>>> peopledf.sort(peopledf.age.desc()).collect()
>>> df.sort("age", ascending=False).collect()
>>> df.orderBy(["age","city"],ascending=[0,1])\
      .collect()
```

Missing & Replacing Values

```
>>> df.na.fill(50).show()
>>> df.na.drop().show()
>>> df.na \
      .replace(10, 20) \
      .show()
```

Replace null values
Return new `df` omitting rows with null values
Return new `df` replacing one value with another

Repartitioning

```
>>> df.repartition(10)\
      .rdd \
      .getNumPartitions()
>>> df.coalesce(1).rdd.getNumPartitions()
```

`df` with 10 partitions

`df` with 1 partition

Running SQL Queries Programmatically

Registering DataFrames as Views

```
>>> peopledf.createGlobalTempView("people")
>>> df.createTempView("customer")
>>> df.createOrReplaceTempView("customer")
```

Query Views

```
>>> df5 = spark.sql("SELECT * FROM customer").show()
>>> peopledf2 = spark.sql("SELECT * FROM global_temp.people")\
                 .show()
```

Output

Data Structures

```
>>> rdd1 = df.rdd
>>> df.toJSON().first()
>>> df.toPandas()
```

Convert `df` into an RDD
Convert `df` into a RDD of string
Return the contents of `df` as Pandas `DataFrame`

Write & Save to Files

```
>>> df.select("firstName", "city")\
      .write \
      .save("nameAndCity.parquet")
>>> df.select("firstName", "age") \
      .write \
      .save("namesAndAges.json",format="json")
```

Stopping SparkSession

```
>>> spark.stop()
```

Inspect Data

```
>>> df.dtypes
>>> df.show()
>>> df.head()
>>> df.first()
>>> df.take(2)
>>> df.schema
```

Return `df` column names and data types
Display the content of `df`
Return first `n` rows
Return first row
Return the first `n` rows
Return the schema of `df`

```
>>> df.describe().show()
>>> df.columns
>>> df.count()
>>> df.distinct().count()
>>> df.printSchema()
>>> df.explain()
```

Compute summary statistics
Return the columns of `df`
Count the number of rows in `df`
Count the number of distinct rows in `df`
Print the schema of `df`
Print the (logical and physical) plans