

Python For Data Science Cheat Sheet

Python Basics

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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)
```

Strings

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

String Operations

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

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]
>>> my_list[-3]
```

Select item at index 1
Select 3rd last item

Slice

```
>>> my_list[1:3]
>>> my_list[1:]
>>> my_list[:3]
>>> my_list[:]
```

Select items at index 1 and 2
Select items after index 0
Select items before index 3
Copy my_list

Subset Lists of Lists

```
>>> my_list2[1][0]
>>> my_list2[1][:2]
```

my_list[list][itemOfList]

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

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

Libraries

Import libraries

```
>>> import numpy
>>> import numpy as np
Selective import
>>> from math import pi
```

pandas Data analysis	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



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 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)
```

Print dictionary keys
Print dictionary keys

```
meta
quality
strain
```

```
>>> pickled_data.values()
>>> print(mat.items())
```

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
```

Explore the HDF5 structure

```
>>> print(data['meta']['Description'].value)
```

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:



NumPy

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

NumPy Arrays

1D array

```
1 2 3
```

2D array

axis 1
axis 0

```
1.5 2 3  
4 5 6
```

3D array

axis 2
axis 1
axis 0

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))  
>>> np.ones((2,3,4),dtype=np.int16)  
>>> d = np.arange(10,25,5)  
  
>>> np.linspace(0,2,9)  
  
>>> e = np.full((2,2),7)  
>>> f = np.eye(2)  
>>> np.random.random((2,2))  
>>> np.empty((3,2))
```

Create an array of zeros
Create an array of ones
Create an array of evenly spaced values (step value)
Create an array of evenly spaced values (number of samples)
Create a constant array
Create a 2X2 identity matrix
Create an array with random values
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  
>>> np.float32  
>>> np.complex  
>>> np.bool  
>>> np.object  
>>> np.string_  
>>> np.unicode_
```

Signed 64-bit integer types
Standard double-precision floating point
Complex numbers represented by 128 floats
Boolean type storing TRUE and FALSE values
Python object type
Fixed-length string type
Fixed-length unicode type

Inspecting Your Array

```
>>> a.shape  
>>> len(a)  
>>> b.ndim  
>>> e.size  
>>> b.dtype  
>>> b.dtype.name  
>>> b.astype(int)
```

Array dimensions
Length of array
Number of array dimensions
Number of array elements
Data type of array elements
Name of data type
Convert an array to a different type

Asking For Help

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

Array Mathematics

Arithmetic Operations

```
>>> g = a - b  
array([[ -0.5,  0. ,  0. ],  
       [ -3. , -3. , -3. ]])  
>>> np.subtract(a,b)  
>>> b + a  
array([[ 2.5,  4. ,  6. ],  
       [ 5. ,  7. ,  9. ]])  
>>> np.add(b,a)  
>>> a / b  
array([[ 0.66666667,  1. ,  1. ],  
       [ 0.25 ,  0.4 ,  0.5 ]])  
>>> np.divide(a,b)  
>>> a * b  
array([[ 1.5,  4. ,  9. ],  
       [ 4. , 10. , 18. ]])  
>>> np.multiply(a,b)  
>>> np.exp(b)  
>>> np.sqrt(b)  
>>> np.sin(a)  
>>> np.cos(b)  
>>> np.log(a)  
>>> e.dot(f)  
array([[ 7. ,  7. ],  
       [ 7. ,  7.]])
```

Subtraction
Subtraction
Addition
Addition
Division
Division
Multiplication
Multiplication
Exponentiation
Square root
Print sines of an array
Element-wise cosine
Element-wise natural logarithm
Dot product

Comparison

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

Element-wise comparison
Element-wise comparison
Array-wise comparison

Aggregate Functions

```
>>> a.sum()  
>>> a.min()  
>>> b.max(axis=0)  
>>> b.cumsum(axis=1)  
>>> a.mean()  
>>> b.median()  
>>> a.corrcoef()  
>>> np.std(b)
```

Array-wise sum
Array-wise minimum value
Maximum value of an array row
Cumulative sum of the elements
Mean
Median
Correlation coefficient
Standard deviation

Copying Arrays

```
>>> h = a.view()  
>>> np.copy(a)  
>>> h = a.copy()
```

Create a view of the array with the same data
Create a copy of the array
Create a deep copy of the array

Sorting Arrays

```
>>> a.sort()  
>>> c.sort(axis=0)
```

Sort an array
Sort the elements of an array's axis

Subsetting, Slicing, Indexing

Also see Lists

Subsetting

```
>>> a[2]  
3  
>>> b[1,2]  
6.0
```

Select the element at the 2nd index
Select the element at row 1 column 2 (equivalent to b[1][2])

Slicing

```
>>> a[0:2]  
array([1, 2])  
>>> b[0:2,1]  
array([ 2.,  5.])
```

Select items at index 0 and 1
Select items at rows 0 and 1 in column 1

```
>>> b[:1]  
array([[1.5, 2., 3.]])  
>>> c[1,...]  
array([[ 3.,  2.,  1.],  
       [ 4.,  5.,  6.]])
```

Select all items at row 0 (equivalent to b[0:1, :])
Same as [1, :, :]

```
>>> a[: :-1]  
array([3, 2, 1])
```

Reversed array a

Boolean Indexing

```
>>> a[a<2]  
array([1])
```

Select elements from a less than 2

Fancy Indexing

```
>>> b[[1, 0, 1, 0], [0, 1, 2, 0]]  
array([ 4. ,  2. ,  6. , 1.5])  
>>> b[[1, 0, 1, 0]][:, [0,1,2,0]]  
array([[ 4. ,  5. ,  6. ,  4. ],  
       [ 1.5,  2. ,  3. , 1.5],  
       [ 4. ,  5. ,  6. ,  4. ],  
       [ 1.5,  2. ,  3. , 1.5]])
```

Select elements (1,0), (0,1), (1,2) and (0,0)
Select a subset of the matrix's rows and columns

Array Manipulation

Transposing Array

```
>>> i = np.transpose(b)  
>>> i.T
```

Permute array dimensions
Permute array dimensions

Changing Array Shape

```
>>> b.ravel()  
>>> g.reshape(3,-2)
```

Flatten the array
Reshape, but don't change data

Adding/Removing Elements

```
>>> h.resize((2,6))  
>>> np.append(h,g)  
>>> np.insert(a, 1, 5)  
>>> np.delete(a, [1])
```

Return a new array with shape (2,6)
Append items to an array
Insert items in an array
Delete items from an array

Combining Arrays

```
>>> np.concatenate((a,d),axis=0)  
array([ 1,  2,  3, 10, 15, 20])  
>>> np.vstack((a,b))  
array([[ 1. ,  2. ,  3. ],  
       [ 1.5,  2. ,  3. ],  
       [ 4. ,  5. ,  6. ]])  
>>> np.r_[e,f]  
>>> np.hstack((e,f))  
array([[ 7.,  7.,  1.,  0.],  
       [ 7.,  7.,  0.,  1.]])  
>>> np.column_stack((a,d))  
array([[ 1, 10],  
       [ 2, 15],  
       [ 3, 20]])  
>>> np.c_[a,d]
```

Concatenate arrays
Stack arrays vertically (row-wise)
Stack arrays vertically (row-wise)
Stack arrays horizontally (column-wise)
Create stacked column-wise arrays
Create stacked column-wise arrays

Splitting Arrays

```
>>> np.hsplit(a,3)  
[array([1]),array([2]),array([3])]  
>>> np.vsplit(c,2)  
[array([[ 1.5,  2. ,  1. ],  
       [ 4. ,  5. ,  6. ]]),  
 array([[ 3.,  2.,  3.],  
       [ 4. ,  5. ,  6.]])]
```

Split the array horizontally at the 3rd index
Split the array vertically at the 2nd index

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Python For Data Science Cheat Sheet

SciPy - Linear Algebra

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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

<pre>>>> np.mgrid[0:5,0:5] >>> np.ogrid[0:2,0:2] >>> np.r_[3,[0]*5,-1:1:10j] >>> np.c_[b,c]</pre>	Create a dense meshgrid Create an open meshgrid Stack arrays vertically (row-wise) Create stacked column-wise arrays
---	---

Shape Manipulation

<pre>>>> np.transpose(b) >>> b.flatten() >>> np.hstack((b,c)) >>> np.vstack((a,b)) >>> np.hsplit(c,2) >>> np.vpsplit(d,2)</pre>	Permute array dimensions Flatten the array Stack arrays horizontally (column-wise) Stack arrays vertically (row-wise) Split the array horizontally at the 2nd index Split the array vertically at the 2nd index
---	--

Polynomials

<pre>>>> from numpy import polyld >>> p = polyld([3,4,5])</pre>	Create a polynomial object
---	----------------------------

Vectorizing Functions

<pre>>>> def myfunc(a): if a < 0: return a*2 else: return a/2 >>> np.vectorize(myfunc)</pre>	Vectorize functions
---	---------------------

Type Handling

<pre>>>> np.real(b) >>> np.imag(b) >>> np.real_if_close(c,tol=1000) >>> np.cast['f'](np.pi)</pre>	Return the real part of the array elements Return the imaginary part of the array elements Return a real array if complex parts close to 0 Cast object to a data type
---	--

Other Useful Functions

<pre>>>> np.angle(b,deg=True) >>> g = np.linspace(0,np.pi,num=5) >>> g[3:] += np.pi >>> np.unwrap(g) >>> np.logspace(0,10,3) >>> np.select([c<4],[c*2]) >>> misc.factorial(a) >>> misc.comb(10,3,exact=True) >>> misc.central_diff_weights(3) >>> misc.derivative(myfunc,1.0)</pre>	Return the angle of the complex argument Create an array of evenly spaced values (number of samples) Unwrap Create an array of evenly spaced values (log scale) Return values from a list of arrays depending on conditions Factorial Combine N things taken at k time Weights for Np-point central derivative Find the n-th derivative of a function at a point
---	--

Linear Algebra

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
>>> linalg.inv(A)
```

Inverse
Inverse

Transposition

```
>>> A.T
>>> A.H
```

Tranpose matrix
Conjugate transposition

Trace

```
>>> np.trace(A)
```

Trace

Norm

```
>>> linalg.norm(A)
>>> linalg.norm(A,1)
>>> linalg.norm(A,np.inf)
```

Frobenius norm
L1 norm (max column sum)
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)
>>> E = np.mat(a).T
>>> linalg.lstsq(F,E)
```

Solver for dense matrices
Solver for dense matrices
Least-squares solution to linear matrix equation

Generalized inverse

```
>>> linalg.pinv(C)
```

Compute the pseudo-inverse of a matrix (least-squares solver)
Compute the pseudo-inverse of a matrix (SVD)

```
>>> linalg.pinv2(C)
```

Creating Sparse Matrices

<pre>>>> F = np.eye(3, k=1) >>> G = np.mat(np.identity(2)) >>> C[C > 0.5] = 0 >>> H = sparse.csr_matrix(C) >>> I = sparse.csc_matrix(D) >>> J = sparse.dok_matrix(A) >>> E.todense() >>> sparse.isspmatrix_csc(A)</pre>	Create a 2X2 identity matrix Create a 2x2 identity matrix Compressed Sparse Row matrix Compressed Sparse Column matrix Dictionary Of Keys matrix Sparse matrix to full matrix 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

<pre>>>> sparse.linalg.expm(I)</pre>	Sparse matrix exponential
---	---------------------------

Asking For Help

```
>>> help(scipy.linalg.diagsvd)
>>> np.info(np.matrix)
```

[Also see NumPy](#)

Matrix Functions

Addition

```
>>> np.add(A,D)
```

Addition

Subtraction

```
>>> np.subtract(A,D)
```

Subtraction

Division

```
>>> np.divide(A,D)
```

Division

Multiplication

```
>>> A @ D
```

Multiplication operator (Python 3)

```
>>> 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 Functions

```
>>> linalg.sinm(D)
```

Matrix sine

```
>>> linalg.cosm(D)
```

Matrix cosine

```
>>> linalg.tanm(A)
```

Matrix tangent

Hyperbolic Trigonometric Functions

```
>>> linalg.sinhm(D)
```

Hypperbolic matrix sine

```
>>> linalg.coshm(D)
```

Hyperbolic matrix cosine

```
>>> linalg.tanhm(A)
```

Hyperbolic matrix tangent

Matrix Sign Function

```
>>> np.signm(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
Unpack eigenvalues
First eigenvector
Second eigenvector
Unpack eigenvalues

```
>>> l1, l2 = la
```

```
>>> v[:,0]
```

```
>>> v[:,1]
```

```
>>> linalg.eigvals(A)
```

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

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Python For Data Science Cheat Sheet

Scikit-Learn

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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', '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)
```

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)
```

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')
```

Naïve 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)
>>> knn.fit(X_train, y_train)
>>> svc.fit(X_train, y_train)
```

Fit the model to the data

Unsupervised Learning

```
>>> k_means.fit(X_train)
>>> pca_model = pca.fit_transform(X_train)
```

Fit the model to the data
Fit to data, then transform it

Prediction

Supervised Estimators

```
>>> y_pred = svc.predict(np.random.random((2,5)))
>>> y_pred = lr.predict(X_test)
>>> y_pred = knn.predict_proba(X_test)
```

Predict labels
Predict labels
Estimate probability of a label

Unsupervised Estimators

```
>>> y_pred = k_means.predict(X_test)
```

Predict labels in clustering algos

Evaluate Your Model's Performance

Classification Metrics

Accuracy Score

```
>>> knn.score(X_test, y_test)
>>> from sklearn.metrics import accuracy_score
>>> accuracy_score(y_test, y_pred)
```

Estimator score method
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)
```

R² 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(1,5),
            "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

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

a	3
b	-5
c	7
d	4

Index

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

DataFrame

Columns			
	Country	Capital	Population
Index	0	Belgium	Brussels
	1	India	New Delhi
	2	Brazil	Brasília

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'])
```

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')
>>> pd.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')
```

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     Brasilia
```

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
Cumulative 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)
```

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Python For Data Science Cheat Sheet

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

			0	1	2
1	5	0	0.233482		
1	5	1	0.390959		
2	4	0	0.184713		
2	4	1	0.237102		
3	3	0	0.433522		
3	3	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": "entry",
                           "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  Brasilia  207847528
3  Brazil  Brasilia  207847528
```

Backward Filling

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

   0   1   2   3   4
0   1   3   3   3   3
1   1   3   3   3   3
2   1   3   3   3   3
3   1   3   3   3   3
4   1   3   3   3   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		data2	
X1	X2	X1	X3
a	11.432	a	20.784
b	1.303	b	NaN
c	99.906	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

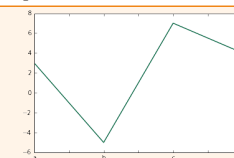
```
>>> df2['Date'] = pd.to_datetime(df2['Date'])
>>> df2['Date'] = pd.date_range('2000-1-1',
                              periods=6,
                              freq='M')
>>> dates = [datetime(2012,5,1), datetime(2012,5,2)]
>>> index = pd.DatetimeIndex(dates)
>>> index = pd.date_range(datetime(2012,2,1),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

Visualization

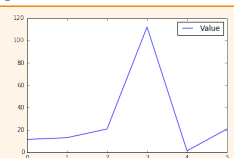
Also see Matplotlib

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

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



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



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Python For Data Science Cheat Sheet

Matplotlib

Learn Python Interactively at [www.DataCamp.com](https://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.



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)
```

3 Plotting Routines

1D Data

```
>>> fig, ax = plt.subplots()
>>> lines = ax.plot(x,y)
>>> ax.scatter(x,y)
>>> axes[0,0].bar([1,2,3],[3,4,5])
>>> axes[1,0].barh([0.5,1,2.5],[0,1,2])
>>> axes[1,1].axhline(0.45)
>>> axes[0,1].axvline(0.65)
>>> ax.fill(x,y,color='blue')
>>> ax.fill_between(x,y,color='yellow')
```

Draw points with lines or markers connecting them
Draw unconnected points, scaled or colored
Plot vertical rectangles (constant width)
Plot horizontal rectangles (constant height)
Draw a horizontal line across axes
Draw a vertical line across axes
Draw filled polygons
Fill between y-values and 0

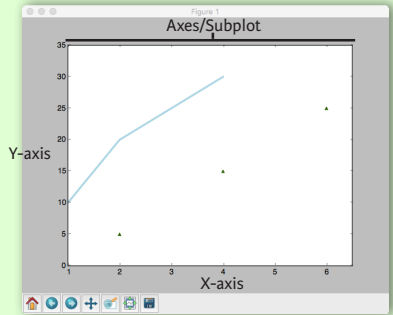
2D Data or Images

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

Colormapped or RGB arrays

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

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)
>>> ax.axis('equal')
>>> ax.set(xlim=[0,10.5],ylim=[-1.5,1.5])
>>> ax.set_xlim(0,10.5)
```

Legends

```
>>> ax.set(title='An Example Axes',
          ylabel='Y-Axis',
          xlabel='X-Axis')
>>> ax.legend(loc='best')
```

Ticks

```
>>> ax.xaxis.set(ticks=range(1,5),
               ticklabels=[3,100,-12,"foo"])
>>> ax.tick_params(axis='y',
                  direction='inout',
                  length=10)
```

Subplot Spacing

```
>>> fig3.subplots_adjust(wspace=0.5,
                       hspace=0.3,
                       left=0.125,
                       right=0.9,
                       top=0.9,
                       bottom=0.1)
```

```
>>> fig.tight_layout()
```

Axis Spines

```
>>> ax1.spines['top'].set_visible(False)
>>> ax1.spines['bottom'].set_position(('outward',10))
```

Add padding to a plot
Set the aspect ratio of the plot to 1
Set limits for x-and y-axis
Set limits for x-axis

Set a title and x-and y-axis labels

No overlapping plot elements

Manually set x-ticks

Make y-ticks longer and go in and out

Adjust the spacing between subplots

Fit subplot(s) in to the figure area

Make the top axis line for a plot invisible
Move the bottom axis line outward

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()
>>> plt.clf()
>>> plt.close()
```

Clear an axis
Clear the entire figure
Close a window



Bokeh

Learn Bokeh **Interactively** at [www.DataCamp.com](https://www.datacamp.com),
taught by Bryan Van de Ven, core contributor

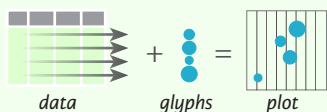


Plotting With Bokeh

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:
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]
>>> y = [6, 7, 2, 4, 5]
>>> p = figure(title="simple line example",
>>>             x_axis_label='x',
>>>             y_axis_label='y')
>>> p.line(x, y, legend="Temp.", line_width=2)
>>> output_file("lines.html")
>>> show(p)
```

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()
```

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)
```



Seaborn

Learn Data Science Interactively at [www.DataCamp.com](https://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")
>>> sns.set_style("whitegrid")
>>> g = sns.lmplot(x="tip", y="total_bill", data=tips, aspect=2)
>>> g = (g.set_axis_labels("Tip", "Total bill (USD)")).set(xlim=(0,10),ylim=(0,100))
>>> plt.title("title")
>>> plt.show(g)
```

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

Axis Grids

```
>>> g = sns.FacetGrid(titanic, col="survived", row="sex")
>>> g = g.map(plt.hist, "age")
>>> sns.factorplot(x="pclass", y="survived", hue="sex", data=titanic)
>>> sns.lmplot(x="sepal_width", y="sepal_length", hue="species", data=iris)
```

Subplot grid for plotting conditional relationships

Draw a categorical plot onto a Facetgrid

Plot data and regression model fits across a FacetGrid

```
>>> h = sns.PairGrid(iris)
>>> h = h.map(plt.scatter)
>>> sns.pairplot(iris)
>>> i = sns.JointGrid(x="x", y="y", data=data)
>>> i = i.plot(sns.regplot, sns.distplot)
>>> sns.jointplot("sepal_length", "sepal_width", data=iris, kind='kde')
```

Subplot grid for plotting pairwise relationships
Plot pairwise bivariate distributions
Grid for bivariate plot with marginal univariate plots

Plot bivariate distribution

Categorical Plots

Scatterplot

```
>>> sns.stripplot(x="species", y="petal_length", data=iris)
>>> sns.swarmplot(x="species", y="petal_length", data=iris)
```

Scatterplot with one categorical variable

Categorical scatterplot with non-overlapping points

Bar Chart

```
>>> sns.barpplot(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"], linestyle=["-", "--"])
```

Show point estimates and confidence intervals as rectangular bars

Boxplot

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

Boxplot

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")
>>> h.set(xlim=(0,5), ylim=(0,5), xticks=[0,2.5,5], yticks=[0,2.5,5])
```

Remove left spine
Set the labels of the y-axis
Set the tick labels for x
Set the axis labels

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



Python For Data Science Cheat Sheet

Keras

Learn Python for data science [Interactively](#) at [www.DataCamp.com](#)



Keras

Keras is a powerful and easy-to-use deep learning library for Theano and TensorFlow that provides a high-level neural networks API to develop and evaluate deep learning models.

A Basic Example

```
>>> import numpy as np
>>> from keras.models import Sequential
>>> from keras.layers import Dense
>>> data = np.random.random((1000,100))
>>> labels = np.random.randint(2,size=(1000,1))
>>> model = Sequential()
>>> model.add(Dense(32,
                    activation='relu',
                    input_dim=100))
>>> model.add(Dense(1, activation='sigmoid'))
>>> model.compile(optimizer='rmsprop',
                 loss='binary_crossentropy',
                 metrics=['accuracy'])
>>> model.fit(data, labels, epochs=10, batch_size=32)
>>> predictions = model.predict(data)
```

Data

Also see NumPy, Pandas & Scikit-Learn

Your data needs to be stored as NumPy arrays or as a list of NumPy arrays. Ideally, you split the data in training and test sets, for which you can also resort to the `train_test_split` module of `sklearn.cross_validation`.

Keras Data Sets

```
>>> from keras.datasets import boston_housing,
                                mnist,
                                cifar10,
                                imdb
>>> (x_train,y_train),(x_test,y_test) = mnist.load_data()
>>> (x_train2,y_train2),(x_test2,y_test2) = boston_housing.load_data()
>>> (x_train3,y_train3),(x_test3,y_test3) = cifar10.load_data()
>>> (x_train4,y_train4),(x_test4,y_test4) = imdb.load_data(num_words=20000)
>>> num_classes = 10
```

Other

```
>>> from urllib.request import urlopen
>>> data = np.loadtxt(urlopen("http://archive.ics.uci.edu/
ml/machine-learning-databases/pima-indians-diabetes/
pima-indians-diabetes.data"),delimiter=",")
>>> X = data[:,0:8]
>>> y = data[:,8]
```

Preprocessing

Sequence Padding

```
>>> from keras.preprocessing import sequence
>>> x_train4 = sequence.pad_sequences(x_train4,maxlen=80)
>>> x_test4 = sequence.pad_sequences(x_test4,maxlen=80)
```

One-Hot Encoding

```
>>> from keras.utils import to_categorical
>>> Y_train = to_categorical(y_train, num_classes)
>>> Y_test = to_categorical(y_test, num_classes)
>>> Y_train3 = to_categorical(y_train3, num_classes)
>>> Y_test3 = to_categorical(y_test3, num_classes)
```

Model Architecture

Sequential Model

```
>>> from keras.models import Sequential
>>> model = Sequential()
>>> model2 = Sequential()
>>> model3 = Sequential()
```

Multilayer Perceptron (MLP)

Binary Classification

```
>>> from keras.layers import Dense
>>> model.add(Dense(12,
                    input_dim=8,
                    kernel_initializer='uniform',
                    activation='relu'))
>>> model.add(Dense(8,kernel_initializer='uniform',activation='relu'))
>>> model.add(Dense(1,kernel_initializer='uniform',activation='sigmoid'))
```

Multi-Class Classification

```
>>> from keras.layers import Dropout
>>> model.add(Dense(512,activation='relu',input_shape=(784,)))
>>> model.add(Dropout(0.2))
>>> model.add(Dense(512,activation='relu'))
>>> model.add(Dropout(0.2))
>>> model.add(Dense(10,activation='softmax'))
```

Regression

```
>>> model.add(Dense(64,activation='relu',input_dim=train_data.shape[1]))
>>> model.add(Dense(1))
```

Convolutional Neural Network (CNN)

```
>>> from keras.layers import Activation,Conv2D,MaxPooling2D,Flatten
>>> model2.add(Conv2D(32,(3,3),padding='same',input_shape=x_train.shape[1:]))
>>> model2.add(Activation('relu'))
>>> model2.add(Conv2D(32,(3,3)))
>>> model2.add(Activation('relu'))
>>> model2.add(MaxPooling2D(pool_size=(2,2)))
>>> model2.add(Dropout(0.25))
>>> model2.add(Conv2D(64,(3,3), padding='same'))
>>> model2.add(Activation('relu'))
>>> model2.add(Conv2D(64,(3,3)))
>>> model2.add(Activation('relu'))
>>> model2.add(MaxPooling2D(pool_size=(2,2)))
>>> model2.add(Dropout(0.25))
>>> model2.add(Flatten())
>>> model2.add(Dense(512))
>>> model2.add(Activation('relu'))
>>> model2.add(Dropout(0.5))
>>> model2.add(Dense(num_classes))
>>> model2.add(Activation('softmax'))
```

Recurrent Neural Network (RNN)

```
>>> from keras.layers import Embedding,LSTM
>>> model3.add(Embedding(20000,128))
>>> model3.add(LSTM(128,dropout=0.2,recurrent_dropout=0.2))
>>> model3.add(Dense(1,activation='sigmoid'))
```

Also see NumPy & Scikit-Learn

Train and Test Sets

```
>>> from sklearn.model_selection import train_test_split
>>> X_train5,X_test5,y_train5,y_test5 = train_test_split(X,
                                                         y,
                                                         test_size=0.33,
                                                         random_state=42)
```

Standardization/Normalization

```
>>> from sklearn.preprocessing import StandardScaler
>>> scaler = StandardScaler().fit(x_train2)
>>> standardized_X = scaler.transform(x_train2)
>>> standardized_X_test = scaler.transform(x_test2)
```

Inspect Model

```
>>> model.output_shape
>>> model.summary()
>>> model.get_config()
>>> model.get_weights()
```

Model output shape
Model summary representation
Model configuration
List all weight tensors in the model

Compile Model

MLP: Binary Classification

```
>>> model.compile(optimizer='adam',
                 loss='binary_crossentropy',
                 metrics=['accuracy'])
```

MLP: Multi-Class Classification

```
>>> model.compile(optimizer='rmsprop',
                 loss='categorical_crossentropy',
                 metrics=['accuracy'])
```

MLP: Regression

```
>>> model.compile(optimizer='rmsprop',
                 loss='mse',
                 metrics=['mae'])
```

Recurrent Neural Network

```
>>> model3.compile(loss='binary_crossentropy',
                  optimizer='adam',
                  metrics=['accuracy'])
```

Model Training

```
>>> model3.fit(x_train4,
              y_train4,
              batch_size=32,
              epochs=15,
              verbose=1,
              validation_data=(x_test4,y_test4))
```

Evaluate Your Model's Performance

```
>>> score = model3.evaluate(x_test,
                           y_test,
                           batch_size=32)
```

Prediction

```
>>> model3.predict(x_test4, batch_size=32)
>>> model3.predict_classes(x_test4,batch_size=32)
```

Save/ Reload Models

```
>>> from keras.models import load_model
>>> model3.save('model_file.h5')
>>> my_model = load_model('my_model.h5')
```

Model Fine-tuning

Optimization Parameters

```
>>> from keras.optimizers import RMSprop
>>> opt = RMSprop(lr=0.0001, decay=1e-6)
>>> model2.compile(loss='categorical_crossentropy',
                  optimizer=opt,
                  metrics=['accuracy'])
```

Early Stopping

```
>>> from keras.callbacks import EarlyStopping
>>> early_stopping_monitor = EarlyStopping(patience=2)
>>> model3.fit(x_train4,
              y_train4,
              batch_size=32,
              epochs=15,
              validation_data=(x_test4,y_test4),
              callbacks=[early_stopping_monitor])
```

