

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	Sum of two variables
>>> x-2	Subtraction of two variables
>>> x*2	Multiplication of two variables
>>> x**2	Exponentiation of a variable
>>> x%2	Remainder of a variable
>>> x/float(2)	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 + 'Init!'
'thisStringIsAwesomeInit!'
>>> '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]
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[:]
```

Subset Lists of Lists

```
>>> my_list2[1][0]
my_list[list[itemOfList]]
>>> my_list2[1][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('i')	Append an item at a time
>>> my_list.remove('i')	Remove an item
>>> del(my_list[0:1])	Remove an item
>>> my_list.reverse()	Reverse the list
>>> my_list.extend('i')	Append an item
>>> my_list.pop(-1)	Remove an item
>>> my_list.insert(0, 'i')	Insert an item
>>> my_list.sort()	Sort the list

Libraries

Import Libraries

>>> import numpy	pandas	Machine learning
>>> import numpy as np	Data analysis	
>>> Selective import	NumPy	matplotlib
>>> from math import pi	Scientific computing	2D plotting

Install Python

ANACONDA	spyder	jupyter
Leading open data science platform	Free IDE that is included with Anaconda	Create and share documents with live code, visualizations, text, ...
powered by Python		

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

>>> my_array[1]	Select item at index 1
>>> my_array[0:2]	Select items at index 0 and 1

Slice

```
>>> my_array[0:2]
array([1, 2])
```

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

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Python For Data Science Cheat Sheet

Jupyter Notebook

Learn More Python for Data Science [Interactively at www.DataCamp.com](https://www.datacamp.com/interactively-at)



Saving/Loading Notebooks

Create new notebook

Make a copy of the current notebook

Save current notebook and record checkpoint

Preview of the printed notebook

Close notebook & stop running any scripts

Open an existing notebook

Rename notebook

Revert notebook to a previous checkpoint

Download notebook as

- Python
- HTML
- Markdown
- .rst
- LaTeX
- PDF

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

Paste cells from clipboard above current cell

Paste cells from clipboard on top of current cell

Revert "Delete Cells" invocation

Merge current cell with the one above

Move current cell up

Adjust metadata underlying the current notebook

Remove cell attachments

Paste attachments of current cell

Copy cells from clipboard to current cursor position

Delete current cells

Spit up a cell from current cursor position

Merge current cell with the one below

Move current cell down

Find and replace in selected cells

Copy attachments of current cell

Insert image in selected 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
Python

R
Rkernel

Julia
Julia

Installing Jupyter Notebook will automatically install the IPython kernel.

Restart kernel

Restart kernel & run all cells

Restart kernel & run all cells

Interrupt kernel

Interrupt kernel & clear all output

Connect back to a remote notebook

Run other installed kernels

Command Mode:

Jupyter MyJupyterNotebook Last Checkpoint: a few seconds ago (unsaved changes)

File Edit View Insert Cell Kernel Widgets Help

Code

1 2 3 4 5 6 7 8 9 10 11 12

In [] :

Edit Mode:

In [] :

Executing Cells

Run selected cell(s)

Run current cells down and create a new one above

Run all cells above the current cell

Change the cell type of current cell

toggle, toggle scrolling and clear all output

Run current cells down and create a new one below

Run all cells

Run all cells below the current cell

toggle, toggle scrolling and clear current outputs

Toggle display of Jupyter logo and filename

Toggle line numbers in cells

Toggle display of cell action icons:

- None
- Edit metadata
- Raw cell format
- Slideshow
- Attachments
- Tags

View Cells

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

Asking For Help

Walk through a UI tour

Edit the built-in keyboard shortcuts

Description of markdown available in notebook

Python help topics

NumPy help topics

Matplotlib help topics

Pandas help topics

List of built-in keyboard shortcuts

Notebook help topics

Information on unofficial Jupyter Notebook extensions

IPython help topics

SciPy help topics

SymPy help topics

About Jupyter Notebook

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.



Numpy

Use the following import convention:

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

Numpy Arrays

1D array

1	2	3
---	---	---

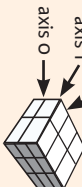
axis 1

1.5	2	3
4	5	6

axis 0

2D array

3D array



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. ,  0.25 ],
       [ 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(E)
array([[ 7. ,  7. ],
       [ 7. ,  7. ]])
```

Subtraction
Subtraction
Addition
Addition
Division
Division
Multiplication
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

```
>>> a[2]
>>> a[1,2]
>>> b[1,2]
>>> b[1,2]
>>> b[1:]
>>> c[1,...]
array([[ 3.,  2.,  1.],
       [ 4.,  5.,  6.]])
>>> a[ : :-1]
array([ 3, 2, 1])
>>> a[a<2]
array([1])
>>> 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.,  4.5],
       [ 1.5,  2.,  3.,  1.5]])
```

Subsetting
Slicing
Boolean Indexing
Fancy Indexing

Select the element at the 2nd index
Select the element at row 0 column 2 (equivalent to b[1][2])
Select items at index 0 and 1
Select items at rows 0 and 1 in column 1
Select all items at row 0 (equivalent to b[0:1, :])
Same as [1, : :]
Reversed array a
Select elements from a less than 2
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
```

Changing Array Shape

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

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]
array([[ 7.,  7.,  1.,  0. ],
       [ 7.,  7.,  1.,  0. ],
       [ 7.,  7.,  0.,  1. ]])
>>> np.hstack((e,f))
array([[ 7.,  7.,  1.,  0. ],
       [ 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 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(a,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

```
>>> np.mgrid[0:5,0:5]
>>> np.ogrid[0:2,0:2]
>>> np.ix_([3],[0]*5,-1:1:10j]
>>> np.c_[b,c]
```

Shape Manipulation

```
>>> np.transpose(b)
>>> b.flatten()
>>> np.hstack((b,c))
>>> np.vstack((a,b))
>>> np.hsplit(c,2)
>>> np.vsplit(d,2)
```

Polynomials

```
>>> from numpy import polyld
>>> p = polyld([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)
>>> np.imag(c)
>>> np.real_if_close(c,tol=1000)
>>> np.cast['F'](np.p1)
```

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

```
>>> 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])
>>> np.select([c<4],[c*2])
>>> misc.factorial(a)
>>> misc.comb(10,3,exact=True)
>>> misc.central_diff_weights(3)
>>> misc.derivative(func,1.0)
```

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

Inverse
Inverse
Transpose matrix
Conjugate transposition
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)
>>> linalg.det(A)
```

Matrix rank
Determinant

Solving linear problems

```
>>> linalg.solve(A,b)
>>> E = np.mat(a).T
>>> linalg.lstsq(D,E)
```

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

Generalized inverse

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

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

Creating Sparse Matrices

```
>>> 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.ispmatrix_csc(A)
```

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)
>>> sparse.linalg.norm(I)
```

Inverse
Norm

Solving linear problems

```
>>> sparse.linalg.solve(H,I)
```

Solver for sparse matrices

Sparse Matrix Functions

```
>>> sparse.linalg.expm(I)
```

Sparse matrix exponential

Asking For Help

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

Also see [NumPy](#)

Matrix Functions

Addition

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

Subtraction

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

Division

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

Multiplication

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

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

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

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

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

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

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

Exponential Functions

```
>>> linalg.expm(A)
```

```
>>> linalg.expm2(A)
```

```
>>> linalg.expm3(D)
```

Logarithm Function

```
>>> linalg.logm(A)
```

Trigonometric Functions

```
>>> linalg.sinn(D)
```

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

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

Hyperbolic Trigonometric Functions

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

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

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

Matrix Sign Function

```
>>> np.sigm(A)
```

Matrix Square Root

```
>>> linalg.sqrtm(A)
```

Arbitrary Functions

```
>>> linalg.funm(A, lambda x: x*x)
```

Decompositions

Eigenvalues and Eigenvectors

```
>>> la, v = linalg.eig(A)
```

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

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

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

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

Singular Value Decomposition

```
>>> U,s,Vh = linalg.svd(B)
```

```
>>> M,N = B.shape
```

```
>>> sig = linalg.diagsvd(s,M,N)
```

LU Decomposition

```
>>> P,L,U = linalg.lu(C)
```

```
>>> P,L,U = linalg.lu(C)
```

Sparse Matrix Decompositions

```
>>> la, v = sparse.linalg.eigs(F,1)
>>> sparse.linalg.svds(H, 2)
```

Eigenvalues and eigenvectors
SVD



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
0	Belgium	Brussels	11190846
1	India	New Delhi	1303171035
2	Brazil	Brasilia	207847528

Index

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

```
>>> data = {'Country': ['Belgium', 'India', 'Brazil'],
           'Capital': ['Brussels', 'New Delhi', 'Brasilia'],
           '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	Get one element
>>> df[1:] Country Capital Population 1 India New Delhi 1303171035 2 Brazil Brasilia 207847528	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 Brasilia Population 207847528 >>> df.ix[:, 'Capital'] 0 Brussels 1 New Delhi 2 Brasilia >>> df.ix[1, 'Capital'] 'New Delhi'	Select single row of subset of rows Select a single column of subset of columns Select rows and columns
>>> 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
>>> df['a'] = 6	Set index a of Series s to 6

Boolean Indexing

Setting

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()
>>> pd.to_sql('myDF', engine)
```

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)
```



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_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', 'M', 'F', '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')
```

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)
```

KMeans

```
>>> 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)
```

Unsupervised Learning

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

Fit the model to the data

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)
```

Unsupervised Estimators

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

Predict labels

Predict labels

Estimate probability of a label

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)
```

Classification Report

```
>>> from sklearn.metrics import classification_report
>>> print(classification_report(y_test, y_pred))
```

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, 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_)
```

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Python For Data Science Cheat Sheet

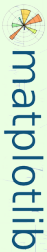
Matplotlib

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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[0,0].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

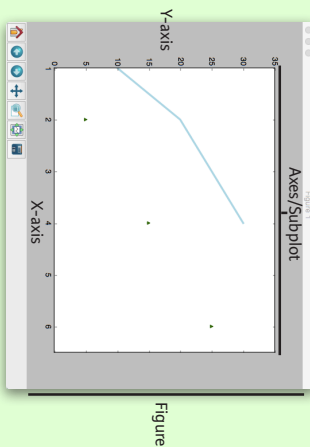
2D Data or Images

```
>>> 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

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',
               xtext=(10.5, 0),
               textcoords='data',
               arrowprops=dict(arrowstyle="->",
                               connectionstyle="arc3"),)
```

Vector Fields

```
>>> axes[0,1].arrow(0,0,0.5,0.5)
>>> axes[1,1].quiver(Y,z)
>>> axes[0,1].streamplot(X,Y,U,V)
```

Add an arrow to the axes

Plot a 2D field of arrows

Plot a 2D field of arrows

Data Distributions

```
>>> ax1.hist(y)
>>> ax3.boxplot(y)
>>> ax3.violinplot(z)
```

Plot a histogram

Make a box and whisker plot

Make a violin plot

```
>>> axes2[0].pcolor(data2)
>>> axes2[0].pcolormesh(data)
>>> CS = plt.contour(Y,X,U)
>>> axes2[2].contourf(data1)
>>> axes2[2] = ax.clabel(CS)
```

Pseudocolor plot of 2D array

Pseudocolor plot of 2D array

Plot contours

Plot filled contours

Label a contour 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='v')
>>> ax.set_xlim(1, 6.5)
>>> plt.savefig('foo.png')
>>> plt.show()
```

Step 1

Step 2

Step 3

Step 3.4

Step 6

Mathtext

```
>>> plt.title('Sigma_i=1^5', fontsize=20)
```

Limits, Legends & Layouts

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

Adjust padding to a plot

Set the aspect ratio of the plot to 1

Set limits for x-axis

Set limits for x-axis

Set a title and x-and y-axis labels

No overlapping plot elements

Ticks

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

Manually set x-ticks

Make y-ticks longer and go in and out

Subplot Spacing

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

Adjust the spacing between subplots

Axis Spines

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

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

Save transparent figures

6 Show Plot

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

Close & Clear

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

Clear an axis

Clear the entire figure

Close a window



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="time",
                  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

Create a figure and one subplot

Seaborn styles

```
>>> sns.set()
>>> sns.set_style("whitegrid")
>>> sns.set_style("ticks",
                  {"ytick.major.size":8,
                   "xtick.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

<pre>>>> 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)</pre>	Subplot grid for plotting conditional relationships Draw a categorical plot onto a FacetGrid Plot data and regression model fits across a FacetGrid
---	---

Categorical Plots

<pre>>>> sns.stripplot(x="species", y="petal_length", data=iris) >>> sns.swarmplot(x="species", y="petal_length", data=iris) >>> sns.barplot(x="sex", y="survived", hue="class", data=titanic) >>> sns.countplot(x="deck", data=titanic, palette="Greens_d")</pre>	Scatterplot with one categorical variable Categorical scatterplot with non-overlapping points Show point estimates and confidence intervals with scatterplot glyphs Show count of observations
--	---

<pre>>>> sns.countplot(x="deck", data=titanic, palette="Greens_d") >>> sns.pointplot(x="class", y="survived", hue="sex", data=titanic, palette={"male": "g", "female": "m"}, markers=["^", "o"], linestyle=["-", "-.-"]) >>> sns.boxplot(x="alive", y="age", hue="adult_male", data=titanic) >>> sns.boxplot(data=iris, orient="h") >>> sns.violinplot(x="age", y="sex", hue="survived", data=titanic)</pre>	Point Plot Show point estimates and confidence intervals as rectangular bars Boxplot Boxplot with wide-form data Violin plot
--	--

Context Functions

<pre>>>> sns.set_context("talk") >>> sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth":2.5}) >>> sns.set_palette("husl", 3) >>> sns.color_palette("husl") >>> flatui = ["#9b59b6", "#3498db", "#95a5a6", "#7fbc8d", "#34495e", "#2ecc71"] >>> sns.set_palette(flatui)</pre>	Set context to "talk" Set context to "notebook", scale font elements and override param mapping Define the color palette Use with with to temporarily set palette Set your own color palette
---	--

Also see [Matplotlib](#)

<pre>>>> 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")</pre>	Subplot grid for plotting pairwise relationships Plot pairwise bivariate distributions Grid for bivariate plot with marginal univariate plots Plot bivariate distribution
---	--

Regression Plots

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

Distribution Plots

<pre>>>> plot = sns.distplot(data.Y, kde=True, color="b")</pre>	Plot univariate distribution
--	------------------------------

Matrix Plots

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

Heatmap

4 Further Customizations

Also see [Matplotlib](#)

<pre>>>> 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), ticks=[0,2.5,5], ticks=[0,2.5,5])</pre>	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

<pre>>>> plt.title("A title") >>> plt.ylabel("Survived") >>> plt.xlabel("Sex") >>> plt.xlim(0,100) >>> plt.ylim(0,10) >>> plt.setp(ax, yticks=[0,5]) >>> plt.tight_layout()</pre>	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](#)

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

Close & Clear

Also see [Matplotlib](#)

<pre>>>> plt.cla() >>> plt.clf() >>> plt.close()</pre>	Clear an axis Clear an entire figure Close a window
---	---



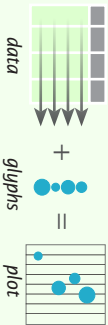


Plotting With Bokeh

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("line.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 CategoricalColormap
>>> color_mapper = CategoricalColormap(
    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", [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 import_row
>>> layout = row(p1, p2, p3)
```

Columns

```
>>> from bokeh.layouts import 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) #>>> show(layout)
>>> save(p1) #>>> save(layout)
```

